Analysis of Atmospheric Deposition of Mercury to the Kinchafoonee Creek Watershed

EXECUTIVE SUMMARY

This document presents an estimate of mercury deposition from the atmosphere to the Kinchafoonee Creek watershed, located in southwestern Georgia. This analysis was done to support the development of a Total Maximum Daily Load (TMDL) limit for Kinchafoonee Creek under the requirements of the Clean Water Act. The purpose of the TMDL is to restore this impaired water body to its designated use - fishable waters. Mercury has been identified as the primary contaminant contributing to the current impairment of Kinchafoonee Creek for which fish consumption advisories have been established. Current information from the recent TMDL studies in the basin indicates that the main source of mercury loading to the Creek and its watershed is derived from atmospheric deposition.

This analysis estimates the level of mercury deposited from the atmosphere to the Kinchafoonee Creek watershed for a baseline period (1994-1996) and for a future date (2010). Our analysis for conditions in the year 2010 assumes that all applicable and currently promulgated standards under the Clean Air Act (CAA) – Section 112 for Maximum Achievable Control Technology Standards (MACTs), Section 111 New Source Performance Standards, and Section 129 Solid Waste Combustion Standards – will have been implemented. The calculations in this analysis indicate that mercury deposition in 2010 to the Kinchafoonee Creek watershed can be reduced approximately 23% to 32% from the baseline period due to implementation of the CAA standards (and including a number of facilities that are known to have closed).

These predicted reductions were derived using the following methodology that calculates and compares the sum of estimated wet and dry deposition to the watershed in the baseline and future years:

1. The analysis begins with an estimate of annual deposition of mercury in precipitation to the watershed, utilizing the data gathered at five Mercury Deposition Network monitors located in Georgia, Alabama, and South Carolina. The analysis also used the results of national atmospheric mercury deposition modeling (using the RELMAP model) done for EPA's 1997 *Mercury Study Report to Congress* (referred to as *The Mercury Study*) to estimate the level of mercury dry deposition to the Kinchafoonee Creek watershed during the baseline period (1994-1996). The national modeling also provides estimates of the relative

contribution to deposition from the various chemical-physical species of mercury, and distinguishes deposition from "U.S. sources" from a general atmospheric "background" which includes international transport, here termed "global sources." The model estimates both wet and dry deposition of divalent mercury gas [Hg(II) or Hg^{2+}] also known as "reactive gaseous mercury" (RGM) from "U.S. sources." This analysis presumes that essentially all the RGM deposited is derived primarily from "local sources," defined here as those sources located within the watershed and in counties within a 100 kilometer distance around the watershed. In addition, deposition of particle-bound mercury and some elemental mercury is derived from U.S. national sources (i.e. at distance >100 km); while global sources contribute gaseous elemental mercury which is gradually oxidized and included in wet deposition.

2. The total RGM emitted (released into the air) from local sources was estimated for the baseline period by using the same emissions data files and species composition tables for mercury emitted as were used to conduct *The Mercury Study* modeling. Local sources include categories such as hospital and medical waste incinerators, electric power plants, pulp and paper mills (recovery furnaces), and residential and industrial boilers. A baseline ratio of RGM deposition to the watershed over the local RGM emissions can then be calculated.

3. For the 2010 analysis, projected RGM emissions in 2010 from local sources were estimated using two factors:

   – Calculated reductions in mercury emissions due to MACT and Waste Combustion controls; and
   – Growth in activity, and thus in emissions, using projected population growth as the indicator.

4. An estimate of RGM deposition to the watershed was calculated for 2010 as proportional to local RGM emissions in 2010 using the same ratio of deposition to emissions as was developed for the baseline (Step 2).

5. The total deposition of all mercury species to the watershed in 2010 was developed by combining the RGM deposition value from step 4 with a proportional estimate of deposition of particle-bound mercury and elemental mercury from national sources, plus an estimate of deposition derived from global sources.

6. Comparison of the value for total mercury deposition estimated in step 1 above, with the value for total mercury deposition calculated in step 5 indicates that a <u>23% to 32% reduction</u> of mercury deposition to the Kinchafoonee Creek watershed is probable over the approximately 15 years from the baseline to 2010, based on currently promulgated standards in the Clean Air Act.

The particulars of this analysis are specific to the Kinchafoonee Creek watershed and the surrounding 100 km area and should not be applied to other geographic areas. If another region of the United States develops an analysis using similar methodology, that area must develop its own specific information on deposition of mercury, plus data on the source categories and emissions present in the area, and estimates of the effects of promulgated regulations on emissions from those sources.

This document also provides a discussion of concepts related to atmospheric modeling and deposition. Some limitations in current approaches are presented along with discussion of how these can affect uncertainties in conclusions.

The document concludes with a brief summary of regulations promulgated to date on emissions sources of mercury under the sections of the Clean Air Act which address maximum achievable control technology (MACT), new source performance standards, and solid waste combustion. In addition, Appendix II provides an informational review of a variety of regulatory and related initiatives to reduce releases of mercury, some of which are enacted but many of which are subject to change as programs continue to develop.

In addition to the regulatory MACT and waste combustion standards mentioned above, and the determination that EPA will seek reductions in mercury emissions from electric power plants that burn coal (see Section 5.3), a number of voluntary programs to reduce mercury releases to the air, water, and land disposal are being developed and implemented in many states. These include:

- Recycling of mercury containing switches and other devices (e.g. from buildings and automobiles);
- Changes in industrial processes to reduce the use of mercury;
- Reduced use of mercury devices in health care, and reduction of mercury in related wastes;
- Substitution of non-mercury materials or devices for current uses, where possible; and
- Distribution of information to facilitate safe collection/recycling of stored mercury and other chemicals in laboratories, schools and colleges, and improved handling of mercury during waste collection efforts.

The effects of these and similar voluntary efforts on current or future reductions in mercury releases to the environment have not been estimated, to date. Therefore, these voluntary programs were not included in this document as part of developing the estimate of reduced emissions and reduced atmospheric deposition of mercury in 2010.

1.0 INTRODUCTION

The purpose of this analysis is to estimate the deposition of mercury to the Kinchafoonee Creek watershed, in kilograms per year (kg/yr) for:

1. A Baseline period (1994-1996); and
2. A future year (2010).

This information is needed for the development of a Total Maximum Daily Load (TMDL) for the Kinchafoonee Creek watershed under the requirements of the Clean Water Act. The purpose of the TMDL is to restore impaired water bodies to their designated uses. Mercury has been identified as the primary contaminant contributing to the current impairment (fish consumption advisories) of the watershed in question.

Mercury in the atmosphere is present primarily in four forms:

1. Gaseous elemental mercury vapor (Hg^0 or zero valent mercury);
2. Gaseous divalent mercury (Hg^{2+}), also called reactive gaseous mercury (RGM);
3. Particulate or particle-bound mercury (both Hg^0 and Hg^{2+}, relative proportion not known, and likely varying with type of particle); and
4. Organic mercury (mostly mono-methylmercury) which can be measured in rainfall, but in amounts so much below the other forms that it will not be discussed further in this document.[1]

As discussed in Volume III of the *Mercury Study Report to Congress* (EPA 1997; hereafter referred to as "*The Mercury Study*"), the deposition of mercury from the atmosphere occurs by two mechanisms:

Wet deposition - In this mechanism, RGM dissolved in rain (or fog or snow) is deposited on to land and/or the surface of water bodies. Particle-bound mercury is also deposited by this mechanism, but is a relatively minor constituent in rain in most areas.

Dry deposition - In this process, both gaseous and particulate forms of mercury are deposited on land, vegetation and/or the surface of water bodies by atmospheric mixing and adsorption, plus settling by gravity. Land uses and type of vegetation cover can affect the net dry deposition. Recent tests indicate that RGM represents the majority of mercury deposited by this mechanism.

The distance from the emission source, the forms of the mercury in the emissions, other pollutants in the emissions and the atmosphere, and the weather patterns of precipitation are

[1]Note that organic forms of mercury are important in the biomagnification of mercury in fish and, ultimately, in the exposure of humans to mercury through fish consumption. However, the amount of organic mercury depositing (as such) from air is considered negligible in comparison to that formed in the aquatic ecosystem.

important factors in determining where mercury released to the air will be deposited. This analysis utilizes the following recently developed information about mercury species and deposition relative to source location (Dvonch et al. 1999):

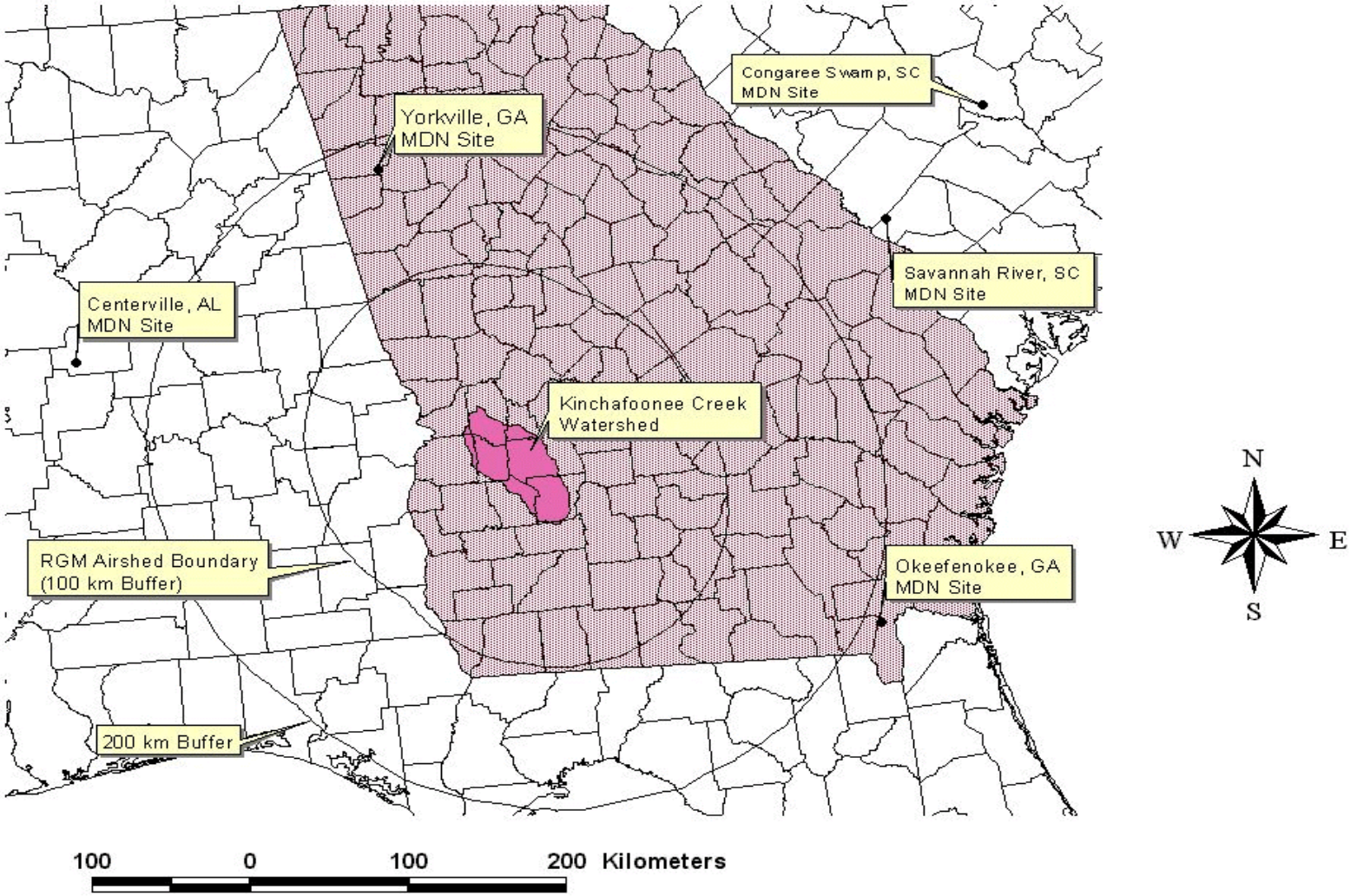
1. RGM released to the air has a relatively short residence time in the lower atmosphere (one to a few days), with the majority of the RGM in emissions being deposited within 100 km of the source.
2. Particle-bound mercury has a somewhat longer residence time in the atmosphere, but is generally deposited to the surface of the earth over longer distances (up to approximately a thousand km.)
3. Gaseous elemental mercury has a relatively long residence time in the atmosphere (approximately one year) and is deposited over international or "global scale" distances. Chemical conversion to the divalent form is important to its deposition, and is affected by other trace elements, gases, and aerosols in the atmosphere.

Because RGM is the dominant form of mercury in both rainfall and most dry deposition processes, and because most of the RGM emitted from anthropogenic sources is deposited relatively quickly, this analysis focuses first on Clean Air Act regulated facilities (and estimates for small stationary sources) within the watershed and within a distance of 100 km around the watershed boundary, and on their emissions of RGM to the air. These stationary facilities and sources are referred to collectively in this document as "local sources," and the area within which they are located is referred to as the "RGM Airshed[2]." Thus, the RGM Airshed extends well beyond the borders of the Kinchafoonee Creek watershed. A graphical illustration of the RGM airshed is provided in Figure 1.

It should be noted that the sources evaluated in this analysis may emit all three forms of inorganic mercury. As noted above, emissions of RGM from a particular source will affect primarily the local area around the source (i.e., within 100 km), while emissions of particulate mercury from the same source are expected to be spread over a much larger area. As such, only a small proportion of the particulate emissions from local sources will be deposited within the RGM airshed. Additional studies within the U.S. have also shown that particulate mercury represents a relatively minor proportion of the mercury emitted by most sources, and contributes only a small to moderate fraction of the mercury in wet or dry deposition. Emissions of gaseous elemental mercury from local sources will also contribute little to the deposition within the RGM airshed, since elemental mercury gas can be transported long distances, and contributes only very small amounts directly to either wet or dry deposition until converted to RGM (a slow

[2] The term "RGM Airshed" is defined for this analysis to include an area extending 100 km from the boundary of the Kinchafoonee Creek watershed, including the area of the watershed (See Figure 1). For this analysis, we located sources of mercury emissions by county. In cases where the 100 km boundary included a fraction of a county, we conservatively included all sources within that county for our analysis. (Also see Section 4.3, "The Airshed" in 4.0 Discussion of Concepts and Uncertainties.)

Figure 1. Kinchafoonee Creek RGM Airshed



process) or adheres to particles, which as noted, tend to be transported and deposited over a much larger area than the RGM airshed or the watershed.

Non-local stationary sources also contribute some of the total mercury depositing to the Kinchafoonee Creek watershed. That is, some proportion of gaseous elemental and particulate mercury from these non-local sources is incorporated in the wet and dry deposition to the watershed. The calculations in this report do include estimated contributions from U.S. sources as a group, outside the RGM airshed, based on results from the RELMAP model. However, to more quantitatively calculate the contribution from these more distant U.S. and global sources would require complex computer air deposition modeling. Such modeling is beyond the scope of this first analysis in support of the TMDL.[3]

2.0 METHODOLOGY FOR THE BASELINE PERIOD AND RGM

2.1 Overview of Baseline Deposition and Baseline Emissions

Analysis of current data on water discharges and estimates of atmospheric deposition indicate that virtually all of the mercury loadings into the Kinchafoonee Creek watershed are caused by atmospheric deposition (both in rainfall and as dry deposition). No new atmospheric deposition monitoring or modeling of mercury to the watershed was performed for this analysis. Rather, we relied on two sources of information: (1) rainfall data from five monitoring sites in the Mercury Deposition Network (MDN), and (2) the results of a previous national modeling study using the Regional Lagrangian Model of Air Pollution (RELMAP.) The results of the RELMAP computer modeling runs are analyzed in detail in *The Mercury Study*, and provide detailed estimates for both wet and dry deposition.

Deposition of mercury in precipitation (wet deposition) onto the Kinchafoonee Creek watershed was estimated by using the average annual value for mercury in rainfall measured at the following five MDN sites: Yorkville and Okefenokee in Georgia; Savannah River and Congaree Swamp in South Carolina; and Centerville in Alabama (see Figure 1 for the locations of the sites). EPA determined that an annual average of all the available data from the five sites would be representative of the watershed (see Section 4.4 for further discussion of this issue). Dry deposition was calculated based on examination of relative wet and dry deposition values from the national RELMAP modeling runs for the Kinchafoonee Creek watershed.

As noted above, recent research indicates that RGM is the dominant form of mercury in both rainfall and most dry deposition processes in the eastern United States. Therefore, EPA

[3]This initial attempt to characterize mercury deposition to the Kinchafoonee Creek Watershed is referred to as the first "Phase" of TMDL analysis, to indicate the reliance on existing information to develop an estimate of deposition to the area. Future work, in the next several years, may utilize complex computer models in conjunction with a more refined emissions inventory for the RGM airshed and possibly including larger areas of Alabama, Georgia and Florida.

determined that RGM is the primary chemical form of mercury depositing to the Kinchafoonee Creek watershed, and that the RGM airshed (i.e., the area within the Kinchafoonee Creek watershed and within 100 km of the watershed boundary) is a reasonable geographic scope for an analysis of sources which contribute significantly to atmospheric deposition of mercury to that watershed.

The national modeling provides numeric estimates for wet and dry deposition of mercury as derived from the chemical species in emissions from U.S. sources, and from international or global "background." This analysis utilizes the relative proportions of the chemical species in deposition, as discussed in *The Mercury Study* analysis of the RELMAP results, to estimate deposition to the watershed that was derived from RGM emissions during the baseline period.

The next step was to relate the baseline deposition of RGM to the baseline emissions of RGM from local sources. The annual emissions data, which were used in the RELMAP modeling to calculate deposition, were developed primarily for the time period 1994-1996 (referred to here as the baseline period.) First, detailed data on emissions of total mercury from the sources in all counties located within the RGM airshed were extracted from the emission inventory developed for the RELMAP modeling in *The Mercury Study*. Then the emissions of total mercury from each of the individual local sources were multiplied by the estimate of RGM percent in emissions from each source category (as provided in *The Mercury Study)* to calculate the total RGM emitted from local sources. Section 2.3 provides a detailed discussion of the emissions analysis.

2.2 Baseline Deposition

This analysis used data from measured wet deposition of mercury at standard monitoring sites, and also the results of EPA's national atmospheric modeling of mercury's transport and deposition across the conterminous United States. Mercury in rainfall is measured by standard methods at sites participating in the Mercury Deposition Network (MDN). Weekly samples are taken and analyzed at a central Laboratory for the MDN, and weekly data tables are available on the Internet web site for the MDN including data for: total precipitation, concentration of total mercury in the collected rainfall, and calculated wet deposition in micrograms per square meter.

There are five MDN sites located within 250 miles of the Kinchafoonee Creek watershed. These sites are: Yorkville and Okefenokee in Georgia; Savannah River and Congaree Swamp in South Carolina; and Centerville in Alabama (See Figure 1 for the location of the sites). Each of these five sites began operating at different times and therefore the amount of available data varies for each site. The Okefenokee and Congaree Swamp sites have data available from 1998-2001. The Yorkville and Centerville sites have data from 2000-2001. And, the Savannah River site has data only from 2001. The average annual total mercury wet deposition using all the data available from the five monitors is 11.4 micrograms per square meter (11.4 ug/m^2), with an average total annual rainfall of 1.11 meters. Total wet deposition is affected by total rainfall and the rainfall average for the five sites is close to long term average annual rainfall at local weather stations (see Section 4.4 for discussion). So the value of 11.4 ug/m^2 was taken as the estimator of

wet deposition for the baseline period. The "baseline" for this analysis is generally taken as 1994-1996, and our analysis considers the baseline period as essentially average in weather and in human economic activities. EPA considers that the chosen wet deposition estimate is suitable because it is related to average rainfall conditions, and because controls on mercury emissions in 1998-2001 were not significantly changed from the baseline period.

Dry deposition of most pollutants cannot be accurately measured or monitored directly, but estimates are calculated based on various modeling approaches using information on concentrations in the ambient air plus detailed weather information. *The Mercury Study* provides a detailed analysis of both wet and dry deposition estimates calculated with the RELMAP computer modeling studies for the conterminous United States. The RELMAP study included input data on mercury emissions in various forms, meteorological data, and algorithms for atmospheric processes. The results of the national RELMAP modeling provide annual wet and dry mercury deposition rates within each cell in a grid over the entire U.S., where each grid-cell is approximately 40 km x 40 km. In this analysis, we examined in detail the RELMAP results which include the area of the Kinchafoonee Creek watershed and also adjacent watersheds in south Georgia. The deposition estimates within each of the grid cells that overlay the Kinchafoonee Creek watershed were averaged to obtain estimates of the wet and dry deposition of mercury within the watershed. The average modeled value for annual **wet** deposition of total mercury was 6.00 ug/m^2 and the average annual **dry** deposition of total mercury was 3.19 ug/m^2. The model estimate for wet deposition is considerably lower than the monitored measurements (from the five MDN sites). EPA considers the measured value to be more representative of actual conditions, because models may be reasonably correct over broad areas yet not necessarily be accurate for a particular location. However the model does provide a ratio of dry deposition to wet deposition equal to 0.53. For additional discussion of resolving differences between model and monitored estimates, see Section 4.4 . Thus, for this analysis of Kinchafoonee Creek watershed, the average **wet** deposition of total mercury was taken as 11.4 micrograms per square meter per year, and the average **dry** deposition of total mercury was taken as 6.04 micrograms per square meter per year.

The Kinchafoonee Creek watershed covers an area of approximately 2,849 square kilometers. Thus, based on the monitored data for wet deposition, and using RELMAP model results to estimate a proportional dry deposition, the total deposition (wet and dry) of mercury in the baseline period to this watershed is approximately 52.3 kilograms (115 pounds) per year.

We used additional analysis of the RELMAP modeling presented in *The Mercury Study* to estimate the mercury deposition to the Kinchafoonee Creek watershed from distant sources of particulate-bound and gaseous elemental mercury. The RELMAP national maps show a distinct pattern: the eastern half of the country receives considerably more deposition than the western half. The analysis in *The Mercury Study* provides ranges of deposition values as percentiles for wet and dry deposition by each form of mercury to the U.S. east of 90° W longitude. (A separate set of deposition percentiles was developed for the U.S. west of 90° W longitude.) A summary of the 50th percentile deposition values from Tables 5-5 and 5-6 in *The Mercury Study* is presented below for the eastern wet and dry mercury deposition values. The 50th percentile values are

generally close (within a factor of 2) to the monitored wet deposition and estimated dry deposition values used for the Kinchafoonee Creek watershed (provided above).

As noted above, the national RELMAP analysis included separate modeling runs for wet deposition and dry deposition for each type of mercury (gaseous elemental, divalent forms (RGM), and particulate forms) and our analysis used these percentile results of different mercury species to generate data on wet and dry deposition by mercury species in the watershed. Specifically, the "percent of sum wet" and "percent of sum dry" columns in Tables 1a and 1b were calculated by dividing the estimated deposition for each form of mercury by the sum within each table (wet or dry). For example, the "percent of sum wet deposition of mercury" for divalent mercury (Hg^{2+}) for U.S. sources was calculated by dividing 2.652 *ug/m²/yr* by 9.927 *ug/m²/yr*, which equals approximately 26.7%.

Table 1a. RELMAP Wet Deposition Estimates from *The Mercury Study* (U.S. East of 90° W Longitude)

Deposition Variable	Deposition at 50th Percentile (ug/m²/yr)	% of Sum Wet Deposition of Mercury
Hg^{2+} (RGM) from U.S. sources	2.652	26.7 %
$Hg_{particle}$ from U.S. sources	1.956	19.7 %
Hg^0 (elem) from U.S. sources	0.181	1.8 %
Hg^0 from global sources	5.138	51.8 %
Sum of the Sources Above	9.927	100 %

Table 1b. RELMAP Dry Deposition Estimates from *The Mercury Study* (U.S. East of 90° W Longitude)

Deposition Variable	Deposition at 50th Percentile (ug/m²/yr)	% of Sum Dry Deposition of Mercury
Hg^{2+} (RGM) from U.S. sources	4.101	98.1 %
$Hg_{particle}$ from U.S. sources	0.078	1.9 %
Sum of the Sources Above	4.179	100 %

The discussion of RELMAP modeling in *The Mercury Study* considers the deposition which results from atmospheric gaseous elemental mercury vapor (Hg^0) in two ways: (1) as emitted from U.S. sources, and (2) as general atmospheric "background" which this analysis refers to as "Hg^0 from global sources." Note that Table 1a, above, represents the contribution to deposition from elemental gaseous mercury, not the relative amounts of mercury which can be measured in ambient air. The RELMAP model calculated the contribution to deposition from "background" elemental mercury separately from elemental mercury emissions from U.S. sources, and considered the "background" contribution to be constantly available across the U.S., though weather patterns strongly affect its atmospheric chemistry and net deposition in different geographic regions. This analysis for the Kinchafoonee Creek watershed notes that elemental mercury is transported internationally, even globally, and thus considers deposition from "background" to represent primarily the effects of global transport, thus very little affected by control measures which reduce mercury emissions specifically within the U.S. See Sections 4.1 and 4.6 for additional discussion of elemental mercury and assumptions related to global transport and deposition within the U.S. As shown in Table 1a, approximately 52% of the total wet deposition of mercury is derived ultimately from "background" or global sources. If the total wet and dry deposition are combined, the global sources contribute about 36% of the total mercury to areas in the eastern U.S. which receive "median" deposition of mercury.

In this analysis, in order to estimate the separate contribution that each species and type of mercury (listed in Table 1 as "deposition variable") makes to total wet deposition and to total dry deposition, EPA utilized the analysis of the RELMAP results, using values in the 50th Percentile distribution for deposition within the eastern half of the U.S. 48 conterminous states. That is, the RELMAP model generated data sets and maps of deposition across the U.S. which would be the result if each type of mercury were the sole contributor to emissions and to deposition. In *The Mercury Study* the range of RELMAP's deposition values for each type of mercury was analyzed into percentiles, and values for the 10th, 50th, and 90th percentiles were presented. (Values for the percentiles are shown in Tables 5-5 and 5-6 of Volume III of *The Mercury Study*.) This analysis for the Kinchafoonee Creek watershed used the values for deposition at the 50th percentile as the main estimators to divide total wet deposition, and total dry deposition, into their constituent source types. EPA recognizes that the deposition values for each deposition variable shown in Table 1 (e.g. wet deposition of Hg^{2+} from U.S. sources) appear to have been modeled and analyzed separately in *The Mercury Study*, and that using these values in one set of calculations to allocate total mercury deposition into source types constitutes an additional step of analysis. EPA considers it valid to use these values of the 50th percentiles as estimators for relative contribution to deposition because these percentiles are based on a coordinated set of RELMAP model runs that utilized the same inputs for emissions, and the same model algorithms for atmospheric chemistry and deposition processes. Also, application of these general estimators (based on the eastern half of the U.S.) for the specific case of the Kinchafoonee Creek watershed is suitable because the national maps for deposition (in *The Mercury Study*) show that the geographic area of the Kinchafoonee Creek watershed is fairly typical of the general eastern U.S. (Also see Section 4.5 "Relating Chemical/ Physical forms of Mercury to Deposition.")

We have an estimate for deposition of total mercury to the Kinchafoonee Creek

watershed, and we wish to use this to obtain an estimate of deposition of RGM to the Kinchafoonee Creek watershed. In order to calculate the deposition of mercury from various origins in relation to the total mercury deposition during the baseline period (1994-1996), we used the percentages shown in Table 1a and Table 1b. That is, the relative percentages are drawn from the results of the national RELMAP modeling and applied to the estimated deposition values derived for the Kinchafoonee Creek watershed. The calculations are done separately for wet deposition and for dry deposition. Specifically, the estimated wet deposition for the Kinchafoonee Creek watershed is calculated by multiplying each value in the column "Percent of Sum Wet Deposition of Mercury" in Table 1a by the value for wet deposition of total mercury to the Kinchafoonee Creek watershed (11.4 ug/m^2/yr.) For the overall relationship, see Equation 1 (Note that each term in Equation 1 represents annual deposition per square meter):

$$[DEP_{Base\text{-}Wet}]_{Total} = [DEP_{Base\text{-}Wet}]_{US\text{-}elem} + [DEP_{Base\text{-}Wet}]_{RGM} + [DEP_{Base\text{-}Wet}]_{Particle} + [DEP_{Base\text{-}Wet}]_{Global} \quad \textbf{(Equation 1)}$$

Where:

$[DEP_{Base\text{-}Wet}]_{Total}$ = the total amount of wet deposition in the baseline period (this is the value derived above for average wet deposition of total mercury within the Kinchafoonee Creek watershed);

$[DEP_{Base\text{-}Wet}]_{US\text{-}elem}$ = the amount of wet deposition in the baseline period due to U.S. sources releasing elemental mercury;

$[DEP_{Base\text{-}Wet}]_{RGM}$ = the amount of wet deposition in the baseline period due to U.S. sources releasing RGM;

$[DEP_{Base\text{-}Wet}]_{Particle}$ = the amount of wet deposition in the baseline period due to U.S. sources of particulate mercury; and

$[DEP_{Base\text{-}Wet}]_{Global}$ = the amount of wet deposition in the baseline period due to global sources of elemental mercury.

Note that the value for $[DEP_{Base\text{-}Wet}]_{Total}$ was determined in this study by using the average annual wet deposition results (total mercury) from rainfall monitoring at the five MDN monitor sites located closest to Kinchafoonee Creek watershed. As described above, for the baseline period the value for the average wet deposition is equal to 11.4 micrograms of total mercury per square meter per year.

Substituting the percentages from Table 1a and the above estimate for $([DEP_{Base\text{-}Wet}]_{Total})$ gives us:

$$[DEP_{Base\text{-}Wet}]_{US\text{-}elem} = (0.018)([DEP_{Base\text{-}Wet}]_{Total}) = (0.018)(11.4 \text{ ug/m}^2\text{/yr}) = 0.205 \text{ ug/m}^2\text{/yr}$$

and

$[DEP_{Base\text{-}Wet}]_{RGM}$ = *(0.267)*($[DEP_{Base\text{-}Wet}]_{Total}$) = (0.267)(11.4 ug/$m^2$/yr) = 3.04 ug/$m^2$/yr

and

$[DEP_{Base\text{-}Wet}]_{Particle}$ = *(0.197)*($[DEP_{Base\text{-}Wet}]_{Total}$) = (0.197)(11.4 ug/$m^2$/yr) = 2.25 ug/$m^2$/yr

and

$[DEP_{Base\text{-}Wet}]_{Global}$ = *(0.518)*($[DEP_{Base\text{-}Wet}]_{Total}$) = (0.518)(11.4 ug/$m^2$/yr) = 5.91 ug/$m^2$/yr

The estimated dry deposition sum the species for the Kinchafoonee Creek watershed is calculated in an analogous fashion (Equation 2) by multiplying the "percent of total dry deposition of mercury" values from Table 1b by the average dry deposition of total mercury determined for the Kinchafoonee Creek watershed, that is 6.04 ug/m^2/yr, presented above.

(In Equation 2, note that each term represents annual deposition per square meter.)

$$[DEP_{Base\text{-}Dry}]_{Total} = [DEP_{Base\text{-}Dry}]_{RGM} + [DEP_{Base\text{-}Dry}]_{Particle} \quad \textbf{(Equation 2)}$$

Where:

$[DEP_{Base\text{-}Dry}]_{Total}$ = the total amount of dry deposition in the baseline period; (this is the value derived above for average dry deposition of total mercury within the Kinchafoonee Creek watershed);

$[DEP_{Base\text{-}Dry}]_{RGM}$ = the amount of dry deposition due to RGM from U.S. sources in the baseline period; and

$[DEP_{Base\text{-}Dry}]_{Particle}$ = the amount of dry deposition due to particulates from U.S. sources in the baseline period.

Note that the value for $[DEP_{Base\text{-}Dry}]_{Total}$ is determined in this study by examining the proportion of dry deposition to wet deposition in the results from the RELMAP model for the Kinchafoonee Creek watershed. As described above in Section 2.1, third paragraph, this value for the average dry deposition during the baseline period is equal to 6.04 micrograms per square meter per year.

Substituting the percentages from Table 1b and the model-based estimate for ($[DEP_{Base\text{-}Dry}]_{Total}$) gives us:

$[DEP_{Base\text{-}Dry}]_{RGM}$ = *(0.981)*($[DEP_{Base\text{-}Dry}]_{Total}$) = (0.981)(6.04 ug/$m^2$/yr) = 5.93 ug/$m^2$/yr

and

$[DEP_{Base\text{-}Dry}]_{Particle} = (0.019)([DEP_{Base\text{-}Dry}]_{Total}) = (0.019)(6.04\ ug/m^2/yr) = 0.115\ ug/m^2/yr$

For the Baseline portion of this analysis (calculating the ratio of RGM deposition to RGM emissions in the baseline period) we are interested in the total wet and dry deposition of RGM to the Kinchafoonee Creek watershed. To obtain total deposition to the Kinchafoonee Creek watershed derived from RGM, we added wet deposition of Hg^{2+} from "U.S. sources" to dry deposition of Hg^{2+} from "U.S. sources," as shown in Equation 3. Throughout this document, EPA considers that nearly all of Hg^{2+} which is emitted from sources will deposit within approximately 100 km of the source. Therefore, the "local" sources within the RGM Airshed for Kinchafoonee Creek account for essentially all the deposition of RGM to the Kinchafoonee Creek watershed which is derived from "U.S. sources"

$$[DEP_{Base}]_{RGM} = [DEP_{Base\text{-}Wet}]_{RGM} + [DEP_{Base\text{-}Dry}]_{RGM} \quad \textbf{(Equation 3)}$$
$$= 3.04\ ug/m^2/yr + 5.93\ ug/m^2/yr$$
$$= 8.97\ ug/m^2/yr$$

The annual total deposition of RGM within the Kinchafoonee Creek watershed , as an average per square meter, is equal to **8.97 ug/m^2/yr** (8.97 micrograms per square meter per year) for the baseline period. The watershed covers an area of approximately 2,849 square kilometers. Thus, based on the analysis above, the total wet and dry deposition of RGM in the baseline period to this watershed area is approximately 25.6 kilograms (56.4 pounds) per year.

2.3 Baseline Emissions Inventory

In this analysis, our procedure is to develop a ratio for the baseline period which will relate the deposition of RGM into the watershed (calculated just above) to the emissions of RGM from local sources. (As discussed above in Section 1.0, "local sources" are Clean Air Act regulated facilities and estimated data for small stationary sources located either within the Kinchafoonee Creek watershed or in counties within 100 km of the watershed boundary.) We examined the mercury emissions data used for the RELMAP modeling in *The Mercury Study* and we summed the emissions of "total" mercury (all species and forms taken together) from all the sources in the RGM airshed. This process is discussed immediately below.

2.3.1 Calculating $[EI_{Base}]$: the emissions of "total" mercury in the baseline period.

To develop the "baseline emissions inventory," EPA examined the emissions inventory (EI) files that were used for the RELMAP modeling in order to identify stationary facilities emitting mercury in Alabama, Georgia and Florida that are in the watershed or in counties within 100 km of the watershed boundary (i.e., within the RGM airshed.) See section 4.3 for additional discussion of the airshed concept and its use in this study. We recognize that there may be additional sources of mercury emissions within the RGM airshed (i.e., mobile sources, landfills, crematories, etc.). However, emissions estimates for these categories of sources in the RGM airshed are currently unavailable (e.g. mobile sources) or are included in "area sources" which

the EI for RELMAP considered to have no emissions of RGM. As stated in Section 1.0, where the RGM airshed distance of 100 km from the watershed included a fraction of a county, EPA conservatively included the entire county and all sources in that county. The source categories located within the RGM airshed for Kinchafoonee Creek include:

- Hospital, Medical, and Infectious Waste Incinerators [49 Sources];
- Coal-fired Electric Utility Boilers [20 Sources];
- Pulp and Paper Plant Recovery Furnaces [10 Sources]
- Battery Production Facilities [2 Sources]
- Carbon Black Production Facilities [1 Source]; and
- Residential and Industrial Boilers [73 Counties].

The emissions inventories available for these source categories provide only the value for the total amount of mercury (total-Hg) released and do not specify the physical and chemical species of mercury (gaseous elemental, divalent, or particulate). This limitation on details of species of mercury emitted is characteristic of essentially all emissions inventories at state and national levels.

The results of this analysis for emissions of "total-mercury" in the 1994-1996 base period are summarized in Table 2 (the four columns to the left.) A detailed presentation listing each individual source is provided in Appendix I. Based on this approach, the total emissions for the baseline period from individual facilities and county estimates for small stationary sources within the Kinchafoonee Creek RGM airshed (***[EI$_{Base}$]***) was determined to be **1431** kilograms per year.

EPA and the States are continuing to refine mercury emissions inventories (EIs), and more recent EIs than those used in *The Mercury Study* are being developed. We recognize that these newer EIs may provide updated estimates of the current mercury emissions in the RGM airshed. However, our analysis relies on general relationships between emissions used for the RELMAP model and the deposition values calculated from that specific inventory. For the Kinchafoonee Creek watershed we supplement the model information with monitor data from measured mercury in rainfall. Future work for a later phase of the TMDL may include development of a more recent and refined EIs to be used in conjunction with an updated modeling analysis.

2.3.2 Calculating $[EI_{Base}]_{RGM}$: emissions of RGM in the baseline period.

To relate deposition of RGM to emissions of RGM, it was necessary to refine the emissions data of "total-mercury" to focus on emissions of RGM. The national RELMAP modeling for *The Mercury Study* developed estimates of the percentage of RGM in the total mercury emitted for each source category. This analysis uses the same percent RGM estimates developed for the national RELMAP modeling, using the values in Table 4-2 in Volume III of *The Mercury Study*. The percentages of RGM in mercury emissions from each source category in the Kinchafoonee Creek RGM airshed are as follows:

- Hospital, Medical, and Infectious Waste Incinerators: 73% ;
- Fossil Fuel Electric Utility Boilers: 30%;
- Pulp and Paper Plant Recovery Furnaces: 30%
- Battery Production Facilities: 10%
- Carbon Black Production Facilities: 10%; and
- Residential and Industrial Boilers 30%.

The Mercury Study RELMAP modeling inventory also included estimated emissions from "area sources[4]" on a per county basis, and assigned a speciated profile of 0% (zero percent) emitted as RGM. Therefore, RGM emissions from area sources were not included in this analysis. (In years after 2000, data in EPA's Toxics Release Inventory will include all stationary sources which emit 10 pounds or more of mercury per year. However, special studies will be required to establish what if any percent of RGM is in such emissions.)

The results of this analysis for RGM emissions in the 1994-1996 base period are summarized in Table 2 in the three columns to the right. A detailed presentation of data on each individual facility and county estimates for small sources is provided in Appendix I. Based on this methodology (summing the data shown in Appendix I), the total RGM emissions for the baseline period from sources within the Kinchafoonee Creek RGM airshed ($[EI_{Base}]_{RGM}$) was determined to be **613.5 kilograms per year**.

2.3.3 Calculating $[DEP_{Base}]_{RGM} / [EI_{Base}]_{RGM}$: the baseline ratio.

The "baseline ratio" expresses a central concept in this overall analysis. In any given year for which information can be gathered on emissions of a pollutant from sources in a region and on deposition of that pollutant to a specific watershed within that region, a ratio can be generated which expresses the relationship of deposition to emissions. Weather patterns from year to year are known to influence deposition, particularly wet deposition which can be measured directly. Dry deposition can only be estimated from a set of ambient measurements (or calculations) and meteorological conditions by using numerical models. EPA considers that for modeling results or annual monitoring data which are based on "average" weather for a year, that the ratio of deposition to emissions will also be representative of average conditions. EPA's analysis for mercury deposition focuses on RGM because most of its deposition is strongly influenced by local sources, and its transport time in the atmosphere is short, generally accepted to be

[4]Use of the term "area sources" here refers to its meaning in the Clean Air Act. An "area source" is any stationary source of hazardous air pollutants (HAP) that is not defined as a "major source." A "major source" is one that emits or has the potential to emit 10 tons or greater per year of any single HAP or 25 tons per year or greater of HAPs in aggregate. (Note that standards under CAA Section 129 are not limited to "major sources".) Thus "area sources" may be a number of small stationary sources, such as residential or commercial heating units, within a given area. The term "area sources" also may refer to net diffusion into the air from land uses, such as plowed land or forestry, where such data have been determined by quantitative studies. Under the CAA, "area sources" do not include mobile sources regulated under Title II of the Act.

approximately one day.

For this analysis of deposition to the Kinchafoonee Creek watershed, the monitored data at the MDN sites have an average which is close to the average precipitation in the region, thus EPA considers that the average wet deposition value of mercury is also reasonably representative of the average for the middle/south Georgia region. The RELMAP model used meteorological data from the year 1989 because the weather patterns across the U.S. for that year were close to average. The emissions inventory data which were input to the model were based on information from individual facilities for the years 1994 to 1996. While the wet deposition data was for later years (1998-2001), both emissions and deposition represent conditions prior to implementation of the MACT or waste-combustion regulations, and thus are suitable for estimating "baseline" conditions in this analysis.

$$\underline{\text{Baseline Ratio}} = \frac{[DEP_{Base}]_{RGM}}{[EI_{Base}]_{RGM}} \qquad \textbf{(Equation 4)}$$

For the Kinchafoonee Creek watershed, the Baseline Ratio = (25.6 kg/yr)/ (613.5 kg/yr) = 0.0417.

A fundamental assumption in this analysis is that in a future year which also has generally average weather conditions will have a ratio of RGM-deposition to RGM-emissions with essentially the same value as the baseline ratio. While this analysis presents expected reductions in emissions of mercury which are projected to occur by a future year, we assume that the general physics and chemistry of mercury in the atmosphere will be little changed, so that the ratio of deposition to emissions will remain essentially the same. Thus the absolute value of the ratio is of limited value in the baseline year, though we present it here for completeness. The main value of the ratio is its use to estimate future deposition, when we can work out a future emissions value. See section 3.3.1 and Equation 5. EPA also assumes that the future year, 2010 in this analysis, will have "average" weather. Of course the actual year of 2010 when it comes may not have average weather, so this analysis is only for a general estimation or example. See Section 4.5 for further discussion.

Table 2. Summary of Mercury Emissions in the Kinchafoonee Creek RGM Airshed During the Baseline Period (1994-1996)						
Source Category	**No. of Sources**	**Total Hg Emissions Baseline Period (kg/yr)**	**% of Total Hg**	**% of Total Hg that is RGM**	**RGM Emissions Baseline Period (kg/yr)**	**% of Total RGM**
Medical Waste Incinerators	**49**	**430.8**	**30%**	**73%**	**314.5**	**51%**
Coal Burning Power Plants	**20**	**670.9**	**47%**	**30%**	**201.3**	**33%**
Battery Production Facilities	**2**	**0.06**	**0.004%**	**10%**	**0.01**	**0.001%**
Carbon Black Production Facilities	**1**	**5.400**	**0.38%**	**10%**	**0.540**	**0.09%**
Pulp and Paper Mills	**10**	**70.3**	**5%**	**30%**	**21.1**	**3%**
Residential/ Industrial Boilers	**73***	**253.8**	**18%**	**30%**	**76.1**	**12%**
Totals	**155**	**1431.3**	**100%**		**613.5**	**100%**

* This value indicates the number of counties in the study area with residential or industrial boilers. The emissions inventory for the residential/industrial boiler source category provides total mercury emissions by county. Of the 73 total counties, 11 counties are in Alabama, 1 county is in Florida and 61 counties are in Georgia.

3.0 METHODOLOGY for YEAR 2010 BASED on PROMULGATED REGULATIONS.

3.1 Overview of Estimating emissions and deposition in the year 2010

To continue this analysis, EPA needed to develop a table of estimated future emissions of RGM from local sources. Then we used a ratio which relates the future deposition of RGM onto the watershed to the future emissions. The year 2010 was selected as the future date because all sources subject to currently promulgated Clean Air Act (CAA) regulations for control of mercury emissions under Maximum Achievable Control Technology (MACT), and under CAA Section 129 for solid waste combustion sources, are required by the CAA to meet the new standards or close by that calendar year, or by earlier years.

To develop estimated future emissions for this analysis, EPA began with the detailed baseline emissions inventory of sources within the Kinchafoonee Creek RGM airshed, and multiplied the emissions of total mercury from each facility by two numbers: (1) a growth factor, and (2) the percent of mercury emitted after implementing additional controls required by the Clean Air Act (CAA) regulations promulgated from the baseline period (1994-‘96) to the present. The growth factor for each source category reflects an estimate of increased activity by that source as the human population and economic activity increase between the baseline period (1994-‘96) and the future year, 2010. As an estimator for industrial activity, EPA used projected growth in the human population, 1995 - 2010. For this analysis, implementation of promulgated CAA controls on mercury affects only one source category in the Kinchafoonee Creek RGM Airshed: Medical Waste Incinerators.

The above calculation gives estimated values for emissions of total mercury in 2010 from individual facilities (and per-county summed values for small boilers) in the airshed. For the next step, EPA used the projected percent of RGM for each source category to estimate the emissions of RGM from each source, and summed to get the projected total RGM emissions in 2010 from sources in the Kinchafoonee Creek RGM airshed.

To obtain an estimate for deposition of RGM in 2010 to the Kinchafoonee Creek watershed, this analysis assumes that the simple proportion of deposition to emissions will remain the same in 2010 as it was in the baseline period. See Equation 5 and further description below in Section 3.3.1. To calculate deposition to the Kinchafoonee Creek watershed of total mercury in 2010 (i.e. all species and forms of mercury in both wet and dry deposition) EPA estimated deposition values for particle-bound and elemental mercury for 2010 and added these to RGM deposition. The estimates for deposition of species other than RGM are based on the RELMAP modeled deposition of each species in the eastern U.S. as analyzed in *The Mercury Study*. Deposition values of these other forms of mercury were derived using the assumption that they are directly proportional to the deposition of RGM in 2010 as they were during the baseline period. The calculation methodology is described below in Section 3.3.2, and the assumptions regarding proportional deposition of the forms of mercury are discussed in Section 4.5.

3.2 Projected Future Emissions Inventory (for 2010) (Calculating $[EI_{2010}]$ and $[EI_{2010}]_{RGM}$)

To develop an estimate for emissions of RGM from local sources, we considered both: probable growth in their activities (thus growth in their emissions), and the reductions in emissions of mercury that will be required for specific source categories by regulations and standards currently promulgated. Also, for the source categories which implement MACT or MACT-like regulation we included a change in the percentage of RGM in the overall emissions if it had changed as the MACT controls were implemented.

To estimate the emissions inventory in the year 2010, we developed "growth factors" for each of the source categories in the RGM airshed. The growth factors use projected human population increase between the years 1995 and 2010 as a surrogate for growth in activity which produces mercury emissions from the source categories in question. The U.S. Census Bureau only provides estimated population increases between 1995 and 2010 at the State level. These population projections were obtained from an U.S. Census Bureau report titled "Population Projections: States, 1995 - 2025" (U.S. Census 1997). EPA developed a "Regional" level for population increases by averaging the values for the eight states in EPA's Region 4 (namely: Alabama, Florida, Georgia, Kentucky, Mississippi, North Carolina, South Carolina, Tennessee.)

We also identified the Maximum Achievable Control Technology (MACT) and Solid Waste Combustion standards (CAA Section 129) applicable to these source categories for which compliance must be achieved between 1995 and 2010, with the amount by which each standard is expected to reduce emissions of total mercury or RGM from each source category. Once EPA developed growth factors and identified expected MACT-related emission reductions, EPA estimated the projected emissions of total-mercury in 2010 by multiplying the baseline period (1994-1996) emissions of total mercury from each individual facility by the growth factor, and multiplied that value by the percent of the baseline total mercury that EPA expects would still be emitted (i.e. 1.00 minus the emission reduction) following implementation of the applicable MACT or waste combustion standard. To estimate the 2010 emissions of RGM ($[EI_{2010}]_{RGM}$), we then multiplied the estimated 2010 total mercury emissions for each individual facility by the percentage of the mercury emitted that is RGM for that source category. The results of these calculations are summarized in Table 3 and are presented for each individual facility in the tables included in Appendix I.

In the particular geographic area of Alabama, Georgia and Florida included in the Kinchafoonee Creek "RGM Airshed," there were six source categories which emitted significant amounts of mercury to the air. Table 2 lists these categories and their emissions. In our calculations of the estimated reductions in future emissions, only those standards which were promulgated by July 2002, were included. That is, this document calculates that expected reductions in emissions by 2010 in the RGM airshed for Kinchafoonee Creek will reflect full implementation of CAA regulations for only one source category: Medical Waste Incinerators (MWI, known more formally as Hospital, Medical and Infectious Waste Incinerators). Section 6.0 gives additional information on the relevant sections of the Clean Air Act, and promulgation

dates for these standards. This document used for calculations only those reductions in emissions which are based on promulgated standards.

In our calculations for all but MWIs, we project that the percentage of total mercury emissions comprised by RGM will remain constant from the baseline period to 2010. For MWIs, implementation of the Clean Air Act standards is expected to result in changes to the RGM percentage. EPA expects that compliance with the CAA standards (reflecting MACT) for MWIs will reduce emissions of RGM from 73% to 50% of the total mercury emissions. All of the RGM percentages for each of the other categories are the same as those used for the RELMAP modeling done for *The Mercury Study*. (See Table 4-2 of Volume III of *The Mercury Study*). For our calculations concerning MWIs we used the pre-MACT RGM percentages for the baseline period and post-MACT RGM percentages for 2010.

Facilities in the baseline emissions inventory that have closed between 1995 and 2000 (based on recent information from Alabama, Georgia and Florida agencies) were considered to have no emissions of mercury in 2010. Each facility which is still active (not closed) in the year 2000 is assumed to still be active in 2010. For purposes of estimation, we assumed that each facility would have growth in its activity the same as the average growth factor for that source category. The growth factors for each category were developed as follows:

1. For medical waste incinerators, it was presumed that most people visiting a medical facility come from nearby populations (this is especially true with county hospitals). Since the state is the lowest division of geographic detail for population increase, the projected percentage increase in state population was used as a surrogate for increase in medical waste generation and the corresponding increase in RGM emissions from each of the hospital incinerators in question. We recognize that the mercury content in the medical wastes being generated may be decreasing due to voluntary recycling and reduction efforts. However, data to support this reduction is not readily available so a conservative approach of assumed growth is included in this analysis. Because of new MACT requirements, most small hospital medical waste incinerators in Georgia were closed by the year 2000. The information on sources in Alabama and Florida was updated where possible and many of the small facilities are also expected to close, but data on operating status since 1996 was not available for some of the sources. For these sources, we conservatively assumed continued operation and typical growth rates for waste incineration and emissions to 2010.

2. For electric utility power plants, it was presumed that energy usage would generally be expected to rise as population over a large area increases, since power companies commonly sell their electricity over a regional (or larger) grid. The projected percentage increase in the population of the Southeast Region was used as a surrogate for RGM emission increases for each of the power plants in question.

3. For pulp and paper plants, battery production facilities and carbon black production facilities, it was presumed that production would increase as population over a larger area increases, since these facilities commonly sell their products to customers over a large area. The projected percentage increase in the Southeast Region's population was used as a surrogate for RGM emission increases at each of the facilities in question.

4. For residential and industrial boilers, the original emissions inventory data was supplied as county totals for mercury emissions. Since it was not known what portion of the county level aggregates is due to industrial and residential boilers, the larger projected growth factor (state versus regional) was used as a conservative estimate of growth in RGM emissions from these sources.

Based on this methodology (See Table 3), for the future emissions analysis EPA calculated that in the year 2010 the emissions of RGM from individual facilities and small or area sources within the RGM airshed ($[EI_{2010}]_{RGM}$) are estimated to be **353.6 kg/yr** (353.6 kilograms per year.)

Table 3. Summary of Mercury Emissions in the Kinchafoonee Creek RGM Airshed Projected for 2010						
Source Category	**No. of Sources Projected in 2010**	**Total Hg Emissions 2010 (kg/yr)**	**% of Total Hg**	**% of Total Hg That is RGM**	**RGM Emissions 2010 (kg/yr)**	**% of Total RGM**
Medical Waste Incinerators	**8**	**1.8**	**0.2%**	**50%**	**0.9**	**0.3%**
Coal Burning Power Plants	**20**	**791.6**	**67%**	**30%**	**237.5**	**67%**
Battery Production Facilities	**2**	**0.1**	**0.007%**	**10%**	**0.008**	**0.00%**
Carbon Black Production Facilities	**1**	**6.37**	**0.539%**	**10%**	**0.637**	**0.180%**
Pulp and Paper Mills	**10**	**82.9**	**7%**	**30%**	**24.9**	**7%**
Residential/ Industrial Boilers	**73***	**298.9**	**25%**	**30%**	**89.7**	**25%**
Total	**114**	**1181.7**	**100%**		**353.6**	**100%**

* This value indicates the number of counties in the study area with residential or industrial boilers. The emissions inventory for the residential/industrial boiler source category provides total mercury emissions by county. Of the 73 total counties, 11 counties are in Alabama, 1 county is in Florida and 61 counties are in Georgia.

3.3 Projected Future Deposition (for the year 2010)

One key goal in this analysis is to estimate deposition of total mercury (all forms, from all sources and areas) to the Kinchafoonee Creek watershed for the year 2010. Our basic assumption is that, for RGM, the ratio of deposition to emissions in the future year will be essentially the same as the ratio of deposition to emissions in the baseline period. Equation 5, below, expresses this relationship. EPA believes this is a reasonable assumption because the ratio represents a general relationship resulting from basic chemistry and physics of atmospheric transport, which will remain essentially the same in future years. That is, we have no reason now to project that the atmospheric conditions in southern Georgia will be greatly different (due to events such as widespread, long-lasting forest fires or major changes in the regional atmospheric chemistry) in 2010 than during the baseline period of 1994-1996. For both time periods, the deposition under analysis is an annual sum of deposition to the Kinchafoonee Creek watershed, and the emissions for both time periods are from Clean Air Act regulated facilities in the "RGM airshed" (the watershed plus the counties within 100 kilometers of the watershed). In addition, we are assuming that the year 2010 will be a year with "average" meteorology for the U.S., comparable to the RELMAP model use of "average" meteorology for the baseline period. (In the RELMAP model runs, the weather data from 1989 was used, because meteorology in that year was generally average across the country). For the MDN monitor data, we consider that the wet deposition amount averaged from four years of data is fairly representative of "average" meteorology because for those four years the average of annual rainfall was similar to long term average rainfall in the area. (For additional discussion, see Section 4.4 .)

3.3.1 Calculating $[DEP_{2010}]_{RGM}$: the future deposition of RGM to the watershed.

To estimate the RGM deposition in 2010 that results from anthropogenic sources within the RGM airshed, the ratio of the modeled RGM deposition in the Baseline period (1994-1996) to the RGM emissions from sources in the RGM airshed for the same period was compared to a similar ratio for 2010 by a simple proportion (**Equation 5)**:

$$\frac{[DEP_{Base}]_{RGM}}{[EI_{Base}]_{RGM}} = \frac{[DEP_{2010}]_{RGM}}{[EI_{2010}]_{RGM}} \qquad \textbf{(Equation 5)}$$

Where:

$[DEP_{Base}]_{RGM}$ = the total annual deposition of RGM to the Kinchafoonee Creek watershed in the baseline period (1994-1996), as calculated above in Equation 3.

$[DEP_{2010}]_{RGM}$ = the projected total annual deposition of RGM to the Kinchafoonee Creek watershed in 2010 (this is the value to be solved for in Equation 5.)

$[EI_{base}]_{RGM}$ = the annual emissions of RGM from local sources within the RGM airshed, based on data gathered during the 1994-1996 base period (Table 2.)

$[EI_{2010}]_{RGM}$ = the projected emissions estimate for RGM during 2010 from a projected inventory of sources within the RGM airshed (Table 3.)

Substituting values for these parameters gives us:

$$[DEP_{2010}]_{RGM} = \frac{[DEP_{Base}]_{RGM} \times [EI_{2010}]_{RGM}}{[EI_{base}]_{RGM}}$$

$$= \frac{(8.97\ ug/m^2/yr) \times (353.6\ kg/yr)}{(613.5\ kg/yr)} = 5.17\ ug/m^2/yr$$

As discussed in Section 2.1, the Kinchafoonee Creek watershed covers an area of approximately 2,849 square kilometers. Thus, the projected total wet and dry deposition of RGM on the watershed in 2010 is approximately 14.7 kilograms (32.4 pounds) per year.

3.3.2 Calculating $[DEP_{2010}]_{Total}$: future deposition of "total" mercury to the watershed.

In Section 2.4.1, we calculated an estimate of the amount of RGM deposited from the air to the Kinchafoonee Creek watershed in a future year, 2010. However, we know that additional sources of mercury from outside the RGM airshed will contribute to the overall depositional loading. In earlier sections, we estimated what this overall loading would be for a baseline period. However, we do not know what the loadings of these additional sources of mercury would be for the future year. Thus, to estimate the deposition of **total** mercury to the watershed for the year 2010, additional steps were needed. Specifically, we added an estimated value for annual deposition from global sources of elemental mercury as well as values for U.S. sources of both elemental and particulate mercury. The procedure we used to obtain these values is provided below.

Calculating $[DEP_{2010}]_{Global}$: Deposition from global background.

Since we had no way to determine how the deposition from global background mercury would change over the approximately 15 year projection period (approximately 1995 to 2010), we presumed that the deposition from globally circulating mercury will be essentially the same during the year 2010 as for the baseline period (1994-1996). This assumption reflects the expectation that, while mercury emissions from fossil fuel combustion for energy production are likely to increase in developing countries, the industrialized nations are expected to continue adding new controls on their sources to reduce mercury emissions. Based on this assumption, EPA projected mercury deposition from global background sources in 2010 to be the same as for

the baseline period (Equation 6):

$$[DEP_{2010}]_{Global} = [DEP_{Base\text{-}Wet}]_{Global} = 5.905 \text{ ug/m}^2\text{/yr} \quad \textbf{(Equation 6)}$$

Where: $[DEP_{Base\text{-}Wet}]_{Global}$ is calculated in the lines following Equation 1 (in Section 2.2 .)

Calculating $[DEP_{2010\text{-}Wet}]_{US\text{-}elem}$, $[DEP_{2010\text{-}Wet}]_{particle}$, and $[DEP_{2010\text{-}Dry}]_{particle}$.

To estimate deposition resulting from U.S. elemental and particulate mercury sources for 2010, EPA presumed that the relative amounts of these species, compared to the amount of RGM deposited from U.S. sources, would not vary between the baseline period and the future year. That is, the relationship among the species of mercury deposited, based on analysis of the RELMAP model runs is used as an estimate for both the baseline and future conditions. From Tables 1a and 1b we obtain the modeled amount of RGM from U.S. sources in wet and dry deposition (50th percentile) during the baseline period, and calculate their sum (Equation 7):

$$[DEP_{Model\text{-}RGM}]_{US\text{-}Total} = [DEP_{Model\text{-}Wet}]_{US\text{-}RGM} + [DEP_{Model\text{-}Dry}]_{US\text{-}RGM} \quad \textbf{(Equation 7)}$$
$$= 2.652 \text{ ug/m}^2\text{/yr} + 4.101 \text{ ug/m}^2\text{/yr}$$
$$= 6.753 \text{ ug/m}^2\text{/yr}$$

Once this value is calculated for total-RGM-deposited, it is compared to the amounts of deposition from U.S.-derived particulate and elemental mercury during the baseline period, using the values at the 50th percentile as given in Tables 1a and 1b. Table 4 presents these values as percentages of the 50th percentile of RELMAP modeled RGM amount.

Table 4. Elemental and Particulate Deposition from U.S. Sources Relative to RGM Deposition from U.S. Sources
From *The Mercury Study* (RELMAP model)
U.S. East of 90° W longitude

Deposition Variable	Deposition at the 50th Percentile (ug/m²/yr)	% (Relative to Total Hg^{2+})
Wet Hg^0 from U.S. sources	0.181	2.7 %
Wet $Hg_{particle}$ from U.S. sources	1.956	29.0 %
Dry $Hg_{particle}$ from U.S. sources	0.078	1.2 %
Total (Wet +Dry) Hg^{2+} from U.S. sources	6.753	100 %

Using these percentages and the assumption that they do not vary between the baseline period and the future year (see Section 4.5 for a discussion of this assumption), we can calculate the amount of future year contribution from U.S. elemental and particulate sources by multiplying the percentages in Table 4 by the estimated amount of RGM deposition to the watershed in 2010 (as estimated above in Section 3.3.1), thus:

$$[DEP_{2010\text{-}Wet}]_{US\text{-}elem} = (0.027)([DEP_{2010}]_{RGM}) = (0.027)(5.17\ ug/m^2/yr) = 0.140\ ug/m^2/yr$$

and

$$[DEP_{2010\text{-}Wet}]_{particle} = (0.290)([DEP_{2010}]_{RGM}) = (0.290)(5.17\ ug/m^2/yr) = 1.50\ ug/m^2/yr$$

and

$$[DEP_{2010\text{-}Dry}]_{particle} = (0.012)([DEP_{2010}]_{RGM}) = (0.012)(5.17\ ug/m^2/yr) = 0.062\ ug/m^2/yr\ .$$

Once these estimated values for deposition of mercury to the Kinchafoonee Creek watershed from U.S. sources were calculated for 2010, the total mercury deposition to the Kinchafoonee Creek watershed, for this analysis, was determined by adding the projected deposition of RGM with projected deposition from U.S. sources and global mercury sources (Equation 8):

Projected Total Hg Deposition to Kinchafoonee Creek Watershed in 2010 =

$$[DEP_{2010}]_{RGM} + [DEP_{2010\text{-}Wet}]_{particle} + [DEP_{2010\text{-}Dry}]_{particle} + [DEP_{2010\text{-}Wet}]_{US\text{-}elem} + [DEP_{2010}]_{global} = \quad \textbf{(Equation 8)}$$

$$(5.17)_{RGM} + (1.50)_{[Wet]Particle} + (0.062)_{[Dry]Particle} + (0.140)_{[Wet]US\text{-}elem} + (5.905)_{Global}$$

$$= 12.78\ ug/m^2/yr\ .$$

Based on this methodology, for this analysis the projected annual deposition of total mercury to the Kinchafoonee Creek watershed for the year 2010 is estimated to be: **12.8 ug/m^2/yr** (12.8 micrograms per square meter per year.)

As discussed in Section 2.1, the watershed covers an area of approximately 2,849 square kilometers. Thus, in this analysis, the projected annual deposition of total mercury in 2010 to the watershed is approximately 36.5 kilograms (80.5 pounds) per year.

3.4 Estimated Reductions in Future Deposition (2010) from the Baseline

Since the total deposition value is based on the relative deposition from different types of sources in the 50th percentile distribution of RELMAP modeled deposition, we conducted a

sensitivity analysis to determine the variability in the projected annual deposition of total mercury to the Kinchafoonee Creek watershed. Specifically, we evaluated the 10th percentile and 90th percentile results from the RELMAP analysis provided in Tables 5-5 and 5-6 of Volume III of *The Mercury Study*. Table 5, below, provides the projected 2010 deposition estimates for the 10th, 50th and 90th percentiles. (Also see Section 4.5 for additional discussion on using these percentiles.)

As can be seen below in Table 5, the estimated percent reductions for total mercury deposition for the Kinchafoonee Creek watershed range from **23 %** to **32 %** over the 15 year period. If we consider only the deposition of RGM over the 15 year period, Table 6, below, shows an estimated **42%** reduction in RGM deposition. The lower estimated percent reduction for total mercury deposition is primarily a result of adding the deposition from the global sources (which we assumed to remain constant from the baseline period to 2010).

Table 5. Total Mercury Deposition Estimates

	Based on 10th Percentile	Based on 50th Percentile	Based on 90th Percentile
Baseline Total Hg Deposition in the Kinchafoonee Creek Watershed ($\mu g/m^2/yr$)	17.44	17.44	17.44
Projected 2010 Total Hg Deposition in the Kinchafoonee Creek Watershed ($\mu g/m^2/yr$)	13.35	12.78	11.87
Percent Reduction	23.4 %	26.8 %	31.9 %

Table 6. RGM Deposition Estimates

	Based on 10th Percentile	Based on 50th Percentile	Based on 90th Percentile
Baseline RGM Deposition in the Kinchafoonee Creek Watershed ($\mu g/m^2/yr$)	8.37	8.97	10.24
Projected 2010 RGM Deposition in the Kinchafoonee Creek Watershed ($\mu g/m^2/yr$)	4.82	5.17	5.90
Percent Reduction	42.4 %	42.4 %	42.4 %

4.0 DISCUSSION OF CONCEPTS AND UNCERTAINTIES

4.1 The RELMAP National Model of Atmospheric Deposition

This analysis of past and future deposition of mercury from the atmosphere depends heavily on the RELMAP modeling; the uncertainties inherent in that modeling remain a part of this process. The national inventory of emissions developed during the early 1990s included many first-time estimates for mercury emissions to the air from many of the individual facilities. During the preparation of the emission inventory data sets for the RELMAP modeling, EPA updated its estimated emissions for several source categories and individual sources, although the techniques to develop quantitative emission estimates remained somewhat limited. For the model calculations, the total emissions had to be allocated between the chemical/physical species of mercury, and this was dependent on limited studies in Europe, and a very few speciated-mercury emissions tests within the U.S. *The Mercury Study* states that:

> *A wide variety of alternate emissions speciations have been simulated for important groups of atmospheric mercury sources in order to test the sensitivity of the RELMAP results to the speciation profiles used. [Bullock et al., 1997B]. This work showed that the RELMAP modeling results are very strongly dependent on the assumed emission speciations.* [Vol.III, p.4-4]

The constraint on modeling produced by limited test data on speciated mercury emissions continues to affect current modeling efforts. Thus the RELMAP results have no more uncertainty in this area than other models available at this time. This analysis utilizes the RELMAP data and results because the RELMAP work was widely reviewed and is considered to provide a useful overall analysis, as discussed in the second paragraph below.

Other aspects of the RELMAP modeling are also considered as contributing to uncertainty, such as the meteorological data and limits of Lagrangian type of computer models. For RELMAP, the meteorological data for the year 1989 were used, since the weather that year was fairly average over most of the U.S. The RELMAP representation of the mercury deposition from "background" was also limited by the constraints of that particular Lagrangian model. Background refers to elemental mercury which is transported internationally, thus the sources for it are "global". The background concentration of mercury in the air is fairly small but the available reservoir in the atmosphere is large. The elemental mercury is removed (deposited) from the atmosphere very slowly, but over a year's time the total deposition is significant. The RELMAP approach may have somewhat overestimated the deposition derived from "global" sources of elemental mercury because the atmospheric background concentration was assumed to remain available at a consistent level, rather than declining as air masses move across the U.S. Likewise, the atmospheric concentration of elemental mercury was not related to inputs into the modeling domain from different compass directions (i.e. across different U.S. borders). Depending on the altitudes and pathways for long-distance inputs of mercury, mixing and precipitation events, and atmospheric chemistry (especially in clouds), newer models using updated atmospheric chemistry for mercury may provide a more refined estimate of deposition

due to mercury transported internationally from global sources.

Notwithstanding the uncertainties noted in the two paragraphs above, EPA has confidence in the underlying studies that EPA used for this current analysis because scientists and interested parties provided detailed and extensive review of *The Mercury Study* and the RELMAP model results and analysis (including their uncertainties) prior to their publication. The background data, including the emissions inventory and the speciation profiles for mercury emissions and the RELMAP computer modeling, have generally been accepted as reasonable and useful to the understanding of atmospheric deposition of mercury in the continental United States.

Also, comparison of the RELMAP results for wet deposition with recent field data indicates that the model's predictions were reasonably correct. In *The Mercury Study*, the RELMAP results for deposition were compared to the available data (1996-1997) for monitored wet deposition of mercury. Since the study was published in 1997, the Mercury Deposition Network (MDN) has been expanded, so that now more data from actual measurements are available. In general, any one year's particular variations in weather (especially precipitation) has considerable influence on measured wet deposition of mercury; so making close comparisons of model results to only a few years' specific data has inherent limitations. In general, the MDN data correlate reasonably well with the RELMAP modeled wet deposition values over much of the U.S. For a detailed discussion of the RELMAP results and MDN measurements for the Kinchafoonee Creek watershed see Section 4.4 below.

4.2 Other Atmospheric Computer Models or Direct Calculation

In conducting this analysis of deposition, EPA considered obtaining atmospheric models newer than RELMAP and preparing an updated emissions inventory, then using these tools to conduct specific modeling focused on the southeastern U.S., or particularly on an area of Georgia, Alabama, and Florida. Three models were considered: Industrial Source Complex Short Term, Version 3 (ISCST3) (for small areas, generally only 100 km across), and the national-scale models Regulatory Modeling System for Aerosols and Deposition (REMSAD) and Hybrid Single Particle Lagrangian Integrated Trajectory (HYSPLIT). However, the working versions currently available for all of these models have calculation routines for mercury chemistry and deposition that present limitations similar to those for RELMAP. The two national-scale models are undergoing updates to their mercury calculation routines; the improved versions of the models are expected to be available late in calendar year 2002 or in 2003. Because of the limitations of each of these other models currently available, EPA decided for this analysis to use the published and reviewed RELMAP modeling results and associated data on emissions.

EPA recognizes that the method of calculation used here, which focuses on reactive gaseous mercury (RGM) and derives an estimated deposition in the future by comparing ratios of RGM deposition to RGM emissions from local sources (those within the RGM airshed), is not

equivalent to a full, computer modeling analysis. However, this approach does provide an estimate of future deposition based on considerations of both expected growth in activity and emissions by the sources, plus estimated reductions achieved through additional controls placed on emissions through the Clean Air Act. The estimated reduction percentages for specific source categories presented in Appendix I were taken directly from the supporting information for the MACT rule-making for each of these source categories. We recognize that we have used national averages for estimated reductions to be achieved by compliance with the MACT standards; these averages are based on the full range of processes and control options within a source category, across the nation. The actual level of reductions in emissions as controls are improved will vary for each source facility depending on the level of control already in place at the time the MACT standard becomes effective. A more in-depth analysis, including a source-by-source evaluation of facilities in the RGM airshed for Kinchafoonee Creek, would be needed to obtain the details of changes in processes or controls and thus reductions in mercury emitted. Because this analysis was needed in a relatively short time, we used the national averages for reductions to be achieved under the new combustion rules. Evaluating each of the individual facilities as to its present processes and control equipment and calculating its particular reductions after applying new controls would require more time and engineering analyses than were available for this first-phase analysis. Such a detailed source-by-source analysis may be developed in the future for further refinements of the emissions inventory and possible additional analyses or computer modeling.

4.3 The Airshed

The term and concept of an "airshed" is less well known than "watershed," and can be somewhat more difficult to define. Basically, an airshed is a geographic area that includes a variety of sources that emit a certain pollutant to the atmosphere, and where the area of the airshed includes all the sources whose emissions contribute to a significant loading or impact to a receptor, by way of atmospheric deposition. Typically the "receptor" can be a watershed (itself a geographic area) or the water surface of a large lake or estuary which receives wet and dry deposition of the pollutant of concern. Different types of pollutants vary considerably in characteristics such as: how long they persist in the air, how far they are transported (in typical weather patterns of a region), and the mechanisms by which they are removed from the air. For example, each chemical species of mercury in gaseous form has different patterns of transport and deposition, and various particles and aerosols with mercury adsorbed have still different patterns. A particular airshed generally surrounds the receptor (watershed or water body) that it affects, particularly in the eastern U.S. where wind directions often come from all compass directions when considered over a full year. The shape of an airshed depends on whether there is a predominant wind direction, and also on how precipitation relates to wind direction. The size of an airshed depends on how far the specific pollutant of concern is distributed from its emission source, and upon defining some numeric level for "significant" deposition. Generally there is a gradient around each facility, where more deposition (per square meter) of the pollutant occurs fairly near the source and then declines as one moves farther away from the source. In some detailed computer models of atmospheric deposition, all the sources that can be "upwind" of the

receptor (watershed) being studied are evaluated as to how far their emissions are transported. Sources situated so that only a small percentage of their emissions are likely to reach the watershed boundary are considered to be outside the airshed of that particular receptor (watershed.) Sources situated such that a significant percentage of their deposition does enter the watershed boundary are considered to be within the airshed of that particular watershed. The setting of "significant percentage" can be complex, but figures of 66% or 75% of emissions are commonly used in particular computer models to define an airshed. It must be understood that calculating or defining an airshed boundary, even with computer modeling, does not mean that there is some sudden change in the importance of sources as one crosses that boundary. Rather the airshed boundary represents an estimate of some degree of significance of contribution to deposition, as one moves along gradients away from the receptor area.

The RELMAP model and the REMSAD and HYSPLIT models, like other computer models that are useful in evaluating atmospheric deposition, do not calculate or define boundaries of specific airsheds to correspond to specific watersheds or water bodies. Generally they are used to model the atmosphere over a large geographic area, much larger than a specific airshed is likely to be, and include all the sources emitting the pollutant of concern. The model calculations incorporate all the emissions, their overall transport and atmospheric reactions, and the resultant deposition to all parts of the geographic area. (Generally the results are expressed as a numeric value for deposition within each square of a grid which is used to subdivide the geographic area).

Here we are concerned with the specific pollutant, RGM or divalent mercury gas, and how near or far from a source it is deposited. This analysis for the Kinchafoonee Creek watershed is based on the RELMAP model, so defining the RGM airshed cannot be derived directly from the model. Rather the results of the model and other research results are consulted to estimate an area within which deposition of RGM can be considered significant. The RELMAP results indicate that significant deposition occurs within two grid squares (each about 40km across) around an individual facility or unit source with large annual emissions, with some deposition continuing into one adjacent grid square (thus to a distance of 80 to 120 km.) Various research publications on mercury, that discuss mercury's chemical species, give a range of significant deposition for RGM that varies from 50 or 60 km to as much as 200 km. For this analysis, the RGM airshed for the Kinchafoonee Creek watershed was set at a distance of 100 km around the watershed (and also includes the watershed area itself.) EPA chose 100 km because it is near the mid range of the various distances proposed for significant deposition of RGM. EPA's goal in defining the RGM airshed in this way was to set a reasonable boundary within which to gather detailed information on sources, and evaluate current and probable future emissions.

In this study, the boundary of the RGM airshed in practical terms includes the boundaries of all the counties that have a portion of their area within 100 km radius of the Kinchafoonee Creek watershed. The information provided by the RELMAP data bases on individual facilities includes the name of the county in which they are located, but not detailed locations. Therefore we did not estimate whether each facility was exactly within a strictly defined distance of 100km,

but included all facilities in the County. This analysis does not assert that only those facilities within the RGM airshed are important for the deposition of RGM. Rather we consider that some RGM, and especially particulate and elemental mercury, emitted from sources within the U.S. but outside this particular airshed also will contribute in some measure to deposition of mercury within the Kinchafoonee Creek watershed. In addition, some deposition will come from mercury reaching the watershed by international transport; that is from "background" or global sources. In future years, possible additional analyses and computer modeling will probably evaluate emissions sources in a considerably larger area than just the watershed and 100 km distance around it.

Alternatively, the RGM airshed could be redefined to extend 200 km around the Kinchafoonee Creek watershed, a distance which reflects some research on transport of RGM. In that case, the analysis would encompass the urban areas of Atlanta, Georgia, Tallahassee, Florida, and Birmingham and Montgomery, Alabama, with the potentially large industrial and utility sources associated with these urban areas. While sources in this larger area, and indeed within the entire southeastern U.S., may contribute to mercury deposition reaching the Kinchafoonee Creek watershed, absent additional modeling EPA cannot estimate their importance relative to sources within the RGM airshed based on 100 km.

In addition, if future analyses are pursued, EPA may develop detailed emissions data from individual sources within a study domain which would consider transport of all species of mercury, not just RGM Source-specific data may be gathered to account for process changes, installation of emissions control equipment or facility closures; such data may show even greater reductions in mercury emissions than EPA can estimate at this time. Speciation profiles for mercury in emissions are critical for modeling, but are not readily available for individual facilities or categories. At this time, measurements of speciated emissions are very limited from most source categories known to emit significant amounts of mercury. (Currently available techniques to measure mercury species quantitatively in emissions are expensive and difficult to apply.) However, the RELMAP estimates of speciated emissions by source category have been widely reviewed, and are used here to compare this analysis to that earlier, more comprehensive study and the published discussion of its results.

4.4 Comparing Monitor Data To Model Estimates.

Mercury in precipitation is monitored by routine collections and chemical analysis at numerous locations (monitoring sites) in the U.S., particularly in the eastern states. Much of this work is coordinated by the Mercury Deposition Network (MDN), a cooperative activity of federal, state, and local agencies, universities, and others, with central coordination through the Illinois State Water Survey. A basic, "transition" network began in 1995 with 13 sites, and in 1996 MDN became a sub-network of the well established National Atmospheric Deposition Program. In the year 2000, over 40 sites were active in the conterminous 48 states. Weekly samples are collected using clean procedures and are analyzed at a central laboratory, with appropriate field and laboratory quality assurance and validation protocols. Within the eight

states of EPA's Region 4, for calendar years 1998, 1999, 2000, and 2001, data is available from 14 sites. Of these sites, five locations are relevant to middle and south Georgia: (1) central South Carolina (Congaree Swamp, in Richland County, near Columbia), (2) southwestern South Carolina (Savannah River, in Barnwell County), (3) southeastern Georgia (Okefenokee National Wildlife Refuge in Charlton County), (4) northeast Georgia (Yorkville in Paulding County, northwest of Atlanta), and (5) central Alabama (Centerville in Bibb County near Birmingham). The other sites in Region 4 states are: one location in southern Mississippi (Oak Grove in Perry County), two locations in southwest Alabama (Bay Road and Delta Elementary which began collecting data in 2001), two locations in eastern North Carolina (Pettigrew State Park & Waccamaw State Park), and four locations in Florida (Chassahowitzka National Wildlife Refuge and three locations from Palm Beach County to Everglades National Park). The nearest sites outside Region 4 are in Louisiana, where three sites began providing data for1999. (See reference for MDN, 2002, for details.)

The following table summarizes the MDN data used in this analysis.

Table 7. Mercury Deposition Network (MDN) Monitoring Data

MDN Site Name	Date Range of Data Collected	Annual Average Total Rainfall (meters)	Annual Average Total Mercury Wet Deposition (ug/m^2)
Centerville, Alabama	Jun 2000 - Dec 2001	1.37	12.1
Yorkville, Georgia	Jun 2000 - Dec 2001	1.14	11.7
Okefenokee, Georgia	Jan 1998 - Dec 2001	1.09	12.8
Savannah River, South Carolina	Feb 2001 - Dec 2001	0.94	10.7
Congaree Swamp, South Carolina	Jan 1998 - Dec 2001	0.99	9.83
Average of 5 sites		1.11	11.43

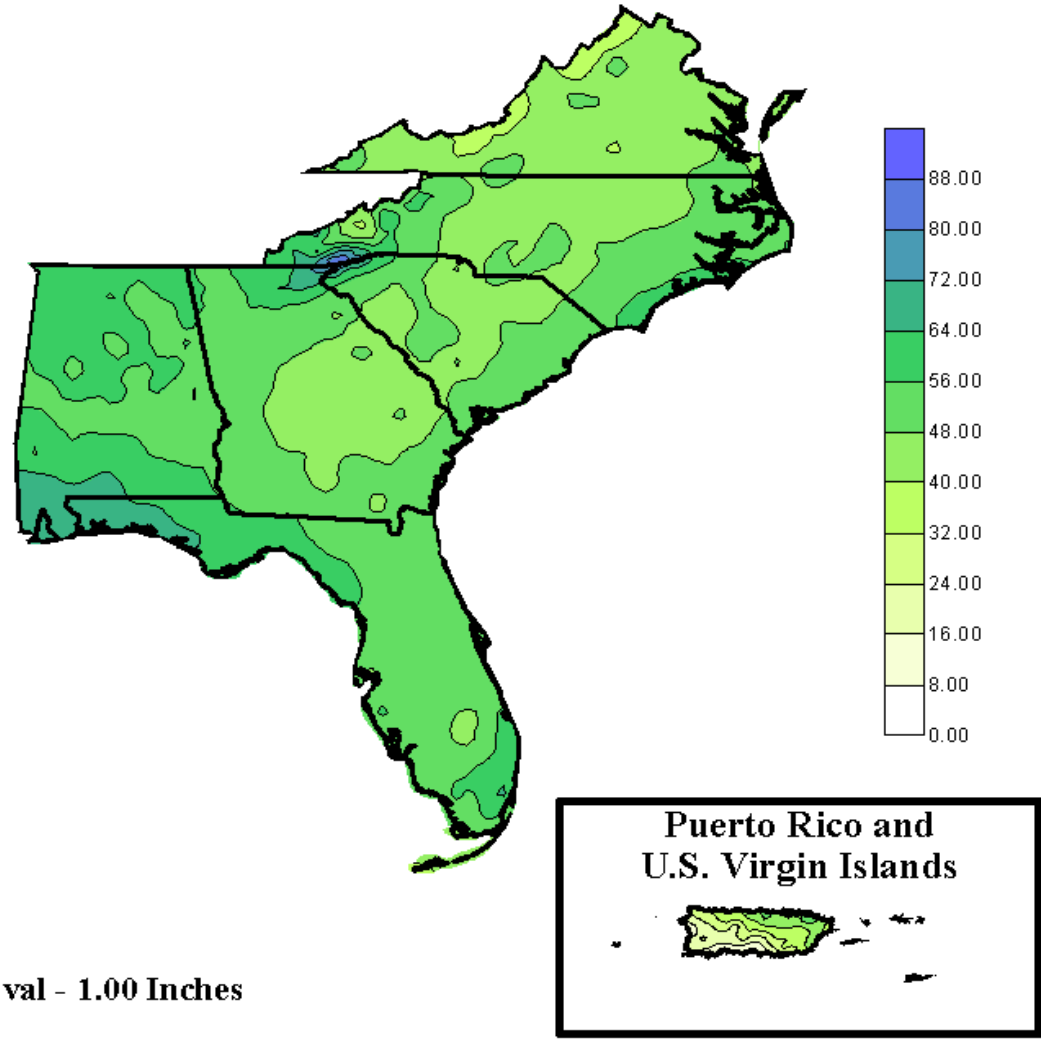
Annual total wet deposition of mercury is generally correlated with total annual precipitation, at least for conditions within the southeastern U.S. The average MDN data for the five sites used in this analysis were compared to annual average precipitation data for the southeastern U.S. Figure 2 presents annual normal precipitation totals for the Southeast using National Weather Service (NWS) data from 1971-2000. This figure shows that the annual normal precipitation totals for the general area of the airshed used in this analysis range from approximately 40 to 56 inches per year (1.0 to 1.4 meters per year).

Figure 2.

Southeast

Precipitation

Annual Normal



Contour Interval - 1.00 Inches

Map produced using NCDC 1971-2000 Normals Data

Data is from NWS First Order and Cooperative Stations.

Map produced by the Southeast Regional Climate Center, February 4, 2002.

Although a formal statistical or numeric analysis has not been done, EPA considers that the average data for the five MDN monitoring sites are sufficiently close to these annual normals. Therefore, the MDN data can be used as an estimate for generally "average" conditions in middle and south Georgia, and can be compared to the RELMAP modeling results.

However, when data is available only for sites that are located long distances from each other, a question arises concerning what extent of area around the sites should be considered to be represented by that location. Because of relative solubility of the various species of mercury found in the atmosphere, the "total-mercury" in precipitation is considered to be over 98% in the form of dissolved RGM (divalent mercury gas, dissolved in ionic form.) RGM also constitutes a similar percentage of dry deposition. Both wet and dry deposition of RGM is considered in this analysis to occur for the most part within 100 kilometers of an emission source. Thus the MDN monitors for wet deposition would be influenced strongly by all sources (facilities or units) within a 100 kilometer distance, with some but lesser influence from other sources at greater distance in the U.S. (especially up to 1000 km distant) plus a significant contribution from "global background" of elemental mercury which is gradually converted to RGM or divalent mercury.

The MDN data represents actual, measured conditions of wet deposition and it differs from the predicted wet deposition from the RELMAP model analyses. The RELMAP results for estimated annual wet deposition to the Kinchafoonee Creek watershed are 6.00 ug/m^2, averaging the appropriate grid squares. This result is considerably less than the MDN average for the five sites, namely 11.4 ug/m^2. (The difference is 5.4 ug/m^2, which is approximately 90 % of 6.00, or approximately 47% of 11.4 ug/m^2.) The RELMAP modeled estimates for wet deposition to the other watersheds in south Georgia are near 6 ug/m^2, though for the St. Mary's watershed the value is over 7 ug/m. These differences between the MDN measurements and the RELMAP model estimates are among the more extreme differences noted in the southeastern states. For the eastern U.S. overall, the RELMAP model predictions for wet deposition have been reasonably close to most of the MDN monitored data for recent years. Thus the RELMAP model results are accepted as reasonably correct in general, though differences from measurements at specific locations can be expected. Because the MDN data are actual measurements, they have been used in this analysis and all of our TMDL-related atmospheric deposition analyses for south Georgia watersheds and for the Ohoopee River watershed in middle Georgia, which were completed in February 2002. In addition, these TMDL analyses have made use of the RELMAP results which calculate annual dry deposition values very close to half of annual wet deposition for these watersheds.

When monitored data and modeled estimates differ, one considers first the likelihood that the emissions inventory data supplied to the model may be inaccurate or non-representative. One or several sources might be missing from the inventory, or might have actual emissions (here in 1998-2001) which are greater than reported to the emissions inventory (here for 1994-1996.) Also, one or several source categories may have a greater percentage of RGM in their emissions than the estimates used in the model; this would increase the local deposition impact of such

sources. EPA has reviewed recent information on emissions sources with the state agencies, and compared the RELMAP emissions inventory (EI) to the 1996 National Toxics Inventory (NTI) and other data as available. This review has found a scattering of differences in emissions numbers provided for RELMAP and reported in other EIs, but no clear identification of missing or greatly under-reported sources which could account for the greater wet deposition at the MDN sites.

Other influences have been suggested, beyond increased local emissions, which could result in monitored wet deposition being greater than the modeled estimate. These include: possible increases in oxidation chemistry in the atmosphere over the geographic area, or greater long-distance transport impacting the area. As a preliminary test of regional influences, a brief examination was made of data at MDN locations across the southeastern states (except for the southern tip of Florida) in comparison to RELMAP deposition estimates. Overall, without attempting to adjust for yearly variation, there was not an obvious pattern that the model underestimates the wet deposition values for all the southeastern MDN locations. So if there are atmospheric processes that increase deposition, they are not discernable across the southeastern coastal states from Louisiana to North Carolina, given the sparse monitoring distribution and few years of data available. Because Florida and southern Georgia are unusual in being close to both the Gulf coast and the Atlantic coast, there may be some marine-derived effects on atmospheric chemistry or transport which affect these areas more than other states. To evaluate such possible mechanisms will require additional atmospheric research and field monitoring, and improved atmospheric models, all of which are expected to become available in the next several years.

4.5 Relating Chemical/Physical Forms of Mercury to Deposition

The RELMAP computer modeling and subsequent analysis of its results provides information which can be used to estimate the how each of the several chemical/physical forms of mercury in emissions contribute to wet deposition and to dry deposition. In this discussion, below, "type" of mercury refers to the chemical species (elemental or divalent), "physical form" refers to its form as gas or particulate, and "source" refers to either U.S. emissions sources or background from "global sources". (See Tables 1a and 1b in section 2.2 above, for the forms and sources of mercury, in the column headed "Deposition Variable".) In the RELMAP modeling studies, separate computational runs were made for emissions of each form of mercury, and the modeled results for deposition in each grid square across the U.S. were mapped and analyzed. For each type of mercury (e.g. elemental mercury from U.S. sources) the range of values of the calculated deposition per square meter were arranged into percentiles, analyzing wet deposition separately from dry deposition. In *The Mercury Study*, data for the 10^{th} Percentile, the 50^{th} Percentile, and the 90^{th} Percentile for each type of mercury were presented for the U.S. as a whole, and also for the eastern portion of the U.S. (EPA, 1997, Vol.III, Tables 5-5 and 5-6.) This analysis for the Kinchafoonee Creek watershed uses the RELMAP results for the eastern U.S. as general estimators of the relative impacts on deposition of the various types of mercury, and applies some additional steps of logic beyond the RELMAP analysis.

This study, as presented above in sections 2.0 through 2.3, focuses on emissions and deposition of RGM, and then relates deposition from the other types of mercury to RGM. This study utilizes the RELMAP values for deposition at the 50th Percentile for each type of mercury to estimate the relative contribution of each type to total deposition. One assumption in this study is that the depositional values at the 50th Percentile of the various types of mercury can be taken as estimators of average deposition such that a sum of their values will provide an estimate of average total deposition of all forms of mercury (referred to as "total-mercury".) EPA considers this to be a reasonable assumption because the 50th percentile values result from a coordinated set of computer runs of the RELMAP model that used the same emissions inventory data and meteorology, and the same algorithms for atmospheric chemistry and processes of deposition. However, using these percentile values as estimators should be considered only a first approximation, used here because there are no other published values by which to compare the relative contribution to deposition which comes from each type of mercury released into the atmosphere.

A related question is whether to use the values (for the eastern U.S.) at the 50th percentiles to represent "average" influence of the types of mercury, rather than using some other set of percentile values. (Here, "average" is meant in the general sense, rather than as a statistical mean.) To check this approach EPA evaluated calculations using different percentiles. EPA examined the deposition values using both the 10th percentile and 90th percentile (shown in Tables 5-5 and 5-6 of Volume III of *The Mercury Study*) and found that they produce roughly similar percentage distributions among the deposition variables, with one exception. The global sources represent a slightly larger fraction of the total wet deposition at the 10th percentile, and a slightly smaller fraction of the total wet deposition at the 90th percentile.[5] With this corroboration, EPA decided that the use of the 50th percentile values provides an appropriate estimator of relative percent contribution to deposition from the various types of mercury emitted.

When estimating <u>future</u> deposition as percentage contributions coming from each type of mercury (e.g. particulate mercury from U.S. Sources), this analysis assumed the relative percentages among types of mercury would remain the same for 2010 as for the baseline period. That is, the same percentages based on RELMAP 50th percentiles were used for the baseline period and for 2010. This approach was taken because currently there are no analyses available which propose different balances of mercury types in the future atmosphere, and how such a balance of mercury species would influence deposition. Also, this document develops only a first phase analysis, so estimating effects of subtle changes which might occur in the future would need more complex analysis, such as computer modeling.

A related question regarding future estimations concerns the relative amounts of the speciated forms of mercury in emissions from sources. As new controls or changes in processes

[5] This observation is expected because in the RELMAP modeling the deposition from the global background was analyzed separately from U.S. mercury sources; its net deposition is influenced by precipitation.

are put in place and the total amount of mercury emitted is reduced, the percentage of RGM emitted may change in relation to the other chemical species or physical types of mercury emitted. Where current engineering analysis for particular source categories has provided numeric estimates for speciated emissions when controls are added, such information was included in our calculations of future emissions. For source categories for which no current engineering estimates have been prepared, this analysis simply assumed the same percentage of RGM in emissions for the future year as was used for the RELMAP data bases for the baseline period. This approach was taken rather than make changes without known basis.

4.6 International Transport (Global Sources) and Reductions in the U.S.

The relative contribution to deposition in the U.S. from global sources of mercury remains controversial. Mercury which is transported in the atmosphere for long distances (internationally) is essentially all in the form of elemental mercury. Elemental mercury is transported globally because it is relatively insoluble in water, it is chemically quite inert, and it does not adsorb readily to most surfaces. Its removal from the air, by deposition, depends primarily on chemical reactions in the atmosphere which convert it to the divalent form (that is, to RGM which is soluble in precipitation) or by adsorption to particles. RELMAP and similar models consider that global sources (which includes current human activities, re-evaporation of previously deposited mercury, and natural releases) provide a low level but ubiquitous "background" of elemental mercury in the air. Current information on mercury's chemical reactions in the atmosphere indicates that conversion to RGM, and thus contribution to deposition, is rather slow under most conditions. However, the RELMAP model considers that the global "background" is always present and some conversion is always occurring. Thus the model calculates over a year's time a significant contribution to deposition comes from the global "background" (about 36% of total deposition to areas in eastern U.S. which receive average mercury deposition.) Research on atmospheric chemistry and transport, and improved national-scale computer modeling, may provide improved estimates of deposition from this "source" within a few years. Until that time, there will remain some uncertainty as to what deposition will be attributed to mercury from international transport, even as the U.S. achieves significant reductions in deposition from domestic sources by applying emissions controls and pollution prevention.

Some research studies have proposed that deposition in some areas of the U.S. which results from international transport (global sources) is more than the RELMAP estimate of 36% of total mercury deposition. Since reductions in emissions from sources in the U.S. will do little to reduce deposition of mercury from global sources, there may be a limit on overall reductions in deposition which national and local efforts can achieve. In contrast, some recent intensive studies in south Florida have indicated that local emissions, within 100 km of a receptor area, can account for most of the mercury deposition (70% or more) which reaches the Florida Everglades. These results suggest that reducing emissions in a local region will probably result in significant reductions in deposition, while deposition resulting from long range transport of elemental

mercury has important but limited impact on the total loading to a watershed. [Dvonch, et al. 1999.] There are some encouraging data from recent studies in south Florida which indicate that reductions in mercury emissions to the air within the state and the U.S. do translate, after some years, into apparent responses within the aquatic ecosystem, including lower mercury levels in fish tissues. That is, reduced domestic emissions can benefit the environment in the U.S., even if global transport continues to contribute to the total deposition.

4.7 Deposition to the Watershed in Geographic Context

A comparison for the baseline period of the estimated value for RGM deposited in the Kinchafoonee Creek watershed (approximately 25.6 kg/yr) with the estimated RGM emissions from sources in the RGM airshed (approximately 613.5 kg/yr) might appear to indicate a rather small amount of net deposition to the area of concern. The ratio indicates that approximately 4% of the calculated RGM emitted from the local sources in the RGM airshed deposits within the watershed area. One way to consider this ratio is to compare the area of the Kinchafoonee Creek watershed itself relative to the total area of the RGM airshed. As stated in Section 1.0, one of the basis tenants for our analysis is that the majority of RGM in emissions is expected to be deposited within 100 km of the source. The area of the watershed is approximately 2,849 km^2, while the area of the RGM airshed (including the watershed) is approximately 56,955 km^2. Thus the watershed area is approximately 5% of the RGM airshed area. Wind data from the airport in Columbus, Georgia, show that wind directions over a full year's time come from all compass directions, though somewhat more commonly from the east and northeast. It is likely that much of the RGM emitted from the sources that are located near the outer edge of the RGM airshed (that is, sources which lie nearly 100 km from the boundary of the watershed) will actually be deposited outside the RGM airshed. That is, winds will disperse some of the RGM from these sources in directions "away from" the watershed, out to distances up to 100 km beyond the RGM airshed. To estimate this larger area that will receive some deposition of RGM from sources that lie within the RGM airshed, a map was generated with an additional boundary "oval" at a distance of 200 km all around the Kinchafoonee Creek watershed. (See Figure 1.) The area within this larger "200 km oval" includes approximately 173,277 km^2. Thus the area within the watershed itself (near 2,849 km^2) is approximately 1.6 % of the entire area within the 200 km oval. Because the sources and the amount of mercury that each source emits are not evenly distributed, the deposition of RGM will not be evenly distributed over the local area. Sources which are located in the watershed itself probably have a larger percentage of their RGM emissions deposited within the watershed than is the case for sources which are within the RGM airshed but some distance from the watershed. Therefore, it appears reasonable that approximately 4 % of the RGM emitted within the RGM airshed will be deposited within the area of the Kinchafoonee Creek watershed.

5.0 ONGOING AND FUTURE REDUCTIONS IN EMISSIONS

5.1 Introduction

As rules and standards pursuant to the Clean Air Act have been developed, proposed, and promulgated since 1990, compliance by emitting sources as well as actions taken voluntarily have already begun to reduce emissions of mercury to the air across the US. EPA expects a combination of ongoing activities will continue to reduce mercury emissions to the air over the next decade. EPA currently regulates emissions of mercury and other hazardous air pollutants under the maximum achievable control technology ("MACT") program of Section 112 of the Clean Air Act, and under a corresponding new source performance standard ("NSPS") program under Sections 111 and 129 of the Act. Section 112 authorizes EPA to address categories of major sources of hazardous air pollutants, including mercury, by issuing emissions standards that, for new sources, are at least as stringent as the emissions control achieved by the best performing similar source in the category, and, for existing sources, are at least as stringent as the average emission limitation achieved by the best performing top 12 percent (or 5 facilities whichever is greater) of similar sources. EPA may also apply these standards to smaller area sources, or choose to apply less stringent standards based on generally available control technologies ("GACT"). Sections 111 and 129 direct EPA to establish MACT-equivalent standards for each category of new and existing solid waste incineration units, regulating several specified air pollutants, including mercury. In addition, in 1996 the US eliminated the use of mercury in most batteries under the Mercury Containing and Rechargeable Battery Management Act. This action is reducing the mercury content of the waste stream which is further reducing mercury emissions from waste combustion. In addition, voluntary measures to reduce use of mercury containing products, such as the voluntary measures committed to by the American Hospital Association, also will contribute to reduced emissions from waste combustion.

5.2 Existing Standards

Based on the EPA's 1996 National Toxics Inventory, the highest emitters of mercury to the air include coal-burning electric utilities, municipal waste combustors, medical waste incinerators, chlor-alkali plants, and hazardous waste combustors. EPA has issued a number regulations under Sections 112 and 111 and 129 to reduce mercury pollution from several of these source categories. Relevant regulations that EPA has established to date under the Clean Air Act include, among others, those listed below.

- The source category of municipal waste combustion (MWC) emitted about 20 percent of total national mercury emissions into the air in 1990. EPA issued final regulations under Sections 111 and 129 for large MWCs on October 31, 1995. Large combustors or incinerators must comply with the rule by December, 2000. These regulations reduce mercury emissions from these facilities by about 90 percent from 1990 emission levels.

- Medical waste incinerators (MWIs) emitted about 24 percent of total national mercury emissions into the air in 1990. EPA issued emission standards under Sections 111 and 129 for MWIs on August 15, 1997. When fully implemented, in 2002, EPA's final rule will reduce mercury emissions from MWIs by about 94 percent from 1990 emission levels.

- Hazardous waste combustors (HWCs) emitted about 2.5 percent of total national mercury emissions in 1990. In September 1999, EPA issued emission standards under Section 112 for these facilities, which include incinerators, cement kilns, and light weight aggregate kilns that burn hazardous waste. When fully implemented, these standards will reduce mercury emissions from HWCs by more than 50 percent from 1990 emission levels. Note that on July 24, 2001, the U.S. Court of Appeals issued a decision vacating the MACT standards for HWCs. In accordance with the court action, EPA promulgated interim emissions standards on February 13, 2002, that temporarily replace the vacated standards until final standards are issued on or before June 14, 2005.

These promulgated regulations when fully implemented and considered together with actions discussed above that will reduce the mercury content of waste are expected to reduce national mercury emissions caused by human activities by about 50 percent from 1990 levels.

5.3 Possible Future Actions

While the expected reductions discussed above will reduce loadings to water bodies, additional air deposition reductions will be needed, in some cases, to achieve the TMDL goal of fishable waters. The National Academy of Science has stated that the benefits of eating fish require a long-term goal of reducing concentrations of methylmercury in fish. Reducing emissions of mercury from additional sources will be an important step toward achieving this goal. A review of active regulatory and related initiatives to reduce mercury emissions from many categories of sources is provided in Appendix II. Additional information on one of the more important sources, electric utilities, is discussed below.

As reported in the *Study of Hazardous Air Pollutant Emissions from Utility Steam Generating Units – Final Report to Congress* (*The Utility Study*, February 1998), electricity generating utility plants, primarily coal-fired units, emitted approximately 51 tons per year of mercury nationwide in 1994. According to *The Mercury Study*, that amount was almost 1/3 of the human-generated mercury emissions in the United States for that year. A more recent estimate gives approximately 48 tons of mercury emitted per year from electric utilities nationwide.

In order to better understand the situation, EPA, in conjunction with the U.S. Department of Energy and other parties, carried out a formal Information Collection Request in 1999 to gather data nationwide on mercury in coal and in emissions from coal-fired utility plants. It was determined that coal-fired units have significant variations in the kind of coal burned, the configuration of the burner, and post-burner pollution control – and that the amount and type of mercury emitted is greatly affected by combinations of these design variations, as well as by other factors relating to combustion.

EPA has found that there are effective ways of controlling mercury emissions from power

plants. Technologies available today and technologies expected to be available in the near future can eliminate most of the mercury from utility emissions in a cost-effective manner. As of late August 2002, however, regulatory requirements have not been defined for the reduction of mercury from the emissions of coal-fired power plants.

In response to this issue, EPA issued a regulatory finding on December 14, 2000, that regulation of HAP from coal and oil-fired electric utility steam generating units is appropriate and necessary. (It should be noted that regulation will not be necessary for units fueled by natural gas, with the exception of combustion turbines.) While this finding did not create regulations, EPA committed to develop and propose MACT regulations by December 15, 2003, with final regulations to follow in approximately one year and implementation an additional three years after that.

EPA expects that a combination of ongoing and future activities under the Clean Air Act will achieve reductions in air deposition of mercury that will enable progress toward achievement of water quality standards for many water bodies within the U.S. These activities include promulgated MACT standards for many source categories, MACT standards under development, and co-benefits when controlling other air pollutants from electric utilities. The activities underway to address mercury are described further in Appendix II: "Emissions Reductions Programs and Initiatives."

In addition, on February 14, 2002, President Bush proposed the Clear Skies Initiative which would result in reductions in emissions of mercury, sulfur dioxide, and nitrogen oxides from U.S. power plants, using a market based approach. Should this initiative be enacted into law, nationwide emissions of mercury from power plants would be reduced significantly from current conditions, thus contributing toward reduced deposition and attainment of water quality standards. In July 2002, Clear Skies legislation was introduced in both the U.S. House of Representatives and the U.S. Senate. It is important to note that, due to the uncertainty of when and how the Clear Skies proposals will be implemented, and how they will relate to the Clean Air Act and MACT standards under development, EPA is not at this time able to develop specific numeric estimates of potential future reductions for the current TMDL analyses based on these proposed bills. Specific details regarding the Clear Skies proposals are available on EPA's website at www.epa.gov/clearskies.

6.0 REFERENCES

Dvonch, J.T, J.R.Graney, G.J. Keeler, and R.K. Stevens. 1999. Use of Elemental Tracers to Source Apportion Mercury in South Florida Precipitation. *Environ. Sci. Technol.* 1999, *33*, 4522-4527.

Mercury Deposition Network (MDN) 2002. See the internet webpage: http://nadp.sws.uiuc.edu/mdn/

U.S. Census Bureau. 1997. *Population Projections: States, 1995 - 2025.* U.S. Department of Commerce, Economics and Statistics Administration. P25-1131. May 1997. [Available at the following webpage: http://www.census.gov/population/www/projections/stproj.html]

U.S. EPA. 1997. *Mercury Study Report to Congress*. Volumes I through VIII. EPA - Office of Air Quality Planning and Standards and Office of Research and Development. December 1997. EPA-452/R-97-005.

U.S. EPA. 1998. *Study of Hazardous Air Pollutant Emissions from Electric Utility Steam Generating Units – Final Report to Congress.* Volumes 1 and 2. February 1998. EPA 453/R-98-004a.

U.S. EPA. 2000. *Federal Register*. Regulatory Finding on the Emissions of Hazardous Air Pollutants From Electric Utility Steam Generating Units; Notice of Regulatory Findings, December 20, 2000, 65 FR 79825 - 79831.

[NOTE: Additional citations to the Federal Register, and to Internet web pages are included in Appendix II.]

Appendix I

RGM Airshed
Emissions Inventory

KINCHAFOONEE CREEK AIRSHED Waste Incinerators

STATE/SOURCE	Facility Type	COUNTY	RGM AIRSHED Pre-MACT (1994/1996) Total Hg Emissions (kg/yr)	%Hg as RGM	RGM AIRSHED Pre-MACT (1994/1996) RGM Hg Emissions (kg/yr)	GROWTH Factor to 2010	Predicted % Reduction due to MACT (Year of MACT Compliance) 1998	Predicted Total Hg Emissions in 2010 (kg/yr)	Predicted RGM Emissions in 2010 (kg/yr)*
GEORGIA									
Berrien County Hospital	Medical Waste Incinerator	Berrien	6.27	73%*	4.57	1.23	94%	Facility Closed	Facility Closed
Coliseum Medical Center	Medical Waste Incinerator	Bibb	13.13	73%*	9.58	1.23	94%	Facility Closed	Facility Closed
HCA Colesium Hospital	Medical Waste Incinerator	Bibb	2.10	73%*	1.53	1.23	94%	Facility Closed	Facility Closed
Central State Hospital	Medical Waste Incinerator	Bleckley	12.26	73%*	8.95	1.23	94%	Facility Closed	Facility Closed
Colquitt Regional Hospital	Medical Waste Incinerator	Colquitt	0.29	73%*	0.21	1.23	94%	Facility Closed	Facility Closed
Memorial Hospital of Adel	Medical Waste Incinerator	Cook	5.42	73%*	3.96	1.23	94%	Facility Closed	Facility Closed
Humana Hospital	Medical Waste Incinerator	Coweta	3.50	73%*	2.55	1.23	94%	Facility Closed	Facility Closed
Newnan Hospital	Medical Waste Incinerator	Coweta	3.85	73%*	2.81	1.23	94%	Facility Closed	Facility Closed
Peachtree Regional Hospital	Medical Waste Incinerator	Coweta	2.10	73%*	1.53	1.23	94%	Facility Closed	Facility Closed
Dodge County Hospital	Medical Waste Incinerator	Dodge	1.79	73%*	1.31	1.23	94%	Facility Closed	Facility Closed
HCA Palmyra Hospital	Medical Waste Incinerator	Dougherty	1.33	73%*	0.97	1.23	94%	Facility Closed	Facility Closed
Palmyra Park Hospital	Medical Waste Incinerator	Dougherty	0.90	73%*	0.65	1.23	94%	Facility Closed	Facility Closed
Phoebe Putney Hospital	Medical Waste Incinerator	Dougherty	33.69	73%*	24.59	1.23	94%	Facility Closed	Facility Closed
Early Memorial Hospital	Medical Waste Incinerator	Early	6.34	73%*	4.62	1.23	94%	Facility Closed	Facility Closed
US Air Force Hospital Robins	Medical Waste Incinerator	Houston	1.12	73%*	0.82	1.23	94%	Facility Closed	Facility Closed
Coliseum Psychiatric Hospital	Medical Waste Incinerator	Jones	3.22	73%*	2.35	1.23	94%	Facility Closed	Facility Closed
Medical Center of Central Georgia	Medical Waste Incinerator	Jones	108.75	73%*	79.39	1.23	94%	Facility Closed	Facility Closed
Mercer University	Medical Waste Incinerator	Jones	0.70	73%*	0.51	1.23	94%	Facility Closed	Facility Closed
South Georgia Medical Center	Medical Waste Incinerator	Lowndes	17.98	73%*	13.12	1.23	94%	Facility Closed	Facility Closed
Flint River Community Hospital	Medical Waste Incinerator	Macon	1.75	73%*	1.28	1.23	94%	Facility Closed	Facility Closed
Meriwether Memorial Hospital	Medical Waste Incinerator	Meriwether	3.01	73%*	2.20	1.23	94%	Facility Closed	Facility Closed
Roosevelt Warm Springs Institute	Medical Waste Incinerator	Meriwether	2.87	73%*	2.09	1.23	94%	Facility Closed	Facility Closed
Miller County Hospital	Medical Waste Incinerator	Miller	4.72	73%*	3.45	1.23	94%	Facility Closed	Facility Closed
Monroe County Hospital	Medical Waste Incinerator	Monroe	0.29	73%*	0.21	1.23	94%	Facility Closed	Facility Closed
Doctors Hospital	Medical Waste Incinerator	Muscogee	2.10	73%*	1.53	1.23	94%	Facility Closed	Facility Closed
Houston Sports Medicine Hospital	Medical Waste Incinerator	Muscogee	0.61	73%*	0.44	1.23	94%	Facility Closed	Facility Closed
Martin Alr Force Base	Medical Waste Incinerator	Muscogee	5.35	73%*	3.91	1.23	94%	Facility Closed	Facility Closed
Medical Center	Medical Waste Incinerator	Muscogee	36.85	73%*	26.90	1.23	94%	Facility Closed	Facility Closed

STATE/SOURCE	Facility Type	COUNTY	RGM AIRSHED Pre-MACT (1994/1996) Total Hg Emissions (kg/yr)	%Hg as RGM	RGM AIRSHED Pre-MACT (1994/1996) RGM Hg Emissions (kg/yr)	GROWTH Factor to 2010	Predicted % Reduction due to MACT (Year of MACT Compliance) 1998	Predicted Total Hg Emissions in 2010 (kg/yr)	Predicted RGM Emissions in 2010 (kg/yr)*
Muscogee Manor Nursing Home	Medical Waste Incinerator	Muscogee	1.07	73%*	0.78	1.23	94%	Facility Closed	Facility Closed
St. Francis Hospital	Medical Waste Incinerator	Muscogee	13.89	73%*	10.14	1.23	94%	Facility Closed	Facility Closed
The Medical Center	Medical Waste Incinerator	Muscogee	25.78	73%*	18.82	1.23	94%	Facility Closed	Facility Closed
West Central Georgia Hospital	Medical Waste Incinerator	Muscogee	10.73	73%*	7.83	1.23	94%	Facility Closed	Facility Closed
Peach County Hospital	Medical Waste Incinerator	Peach	0.29	73%*	0.21	1.23	94%	Facility Closed	Facility Closed
Patterson Hospital	Medical Waste Incinerator	Randolph	1.40	73%*	1.02	1.23	94%	Facility Closed	Facility Closed
Spalding Regional Hospital	Medical Waste Incinerator	Spalding	3.50	73%*	2.55	1.23	94%	Facility Closed	Facility Closed
Telfair County Hospital	Medical Waste Incinerator	Telfair	1.82	73%*	1.33	1.23	94%	Facility Closed	Facility Closed
John D Archbold Memorial Hospital	Medical Waste Incinerator	Thomas	13.48	73%*	9.84	1.23	94%	Facility Closed	Facility Closed
Southwestern State Hospital	Medical Waste Incinerator	Thomas	31.01	73%*	22.64	1.23	94%	Facility Closed	Facility Closed
West Georgia Medical Center	Medical Waste Incinerator	Troup	13.28	73%*	9.69	1.23	94%	Facility Closed	Facility Closed
Upson County Hospital	Medical Waste Incinerator	Upson	4.17	73%*	3.04	1.23	94%	Facility Closed	Facility Closed
Worth County Hospital	Medical Waste Incinerator	Worth	1.75	73%*	1.28	1.23	94%	Facility Closed	Facility Closed
		Georgia Totals	**404.41**		**295.22**			**0.00**	**0.00**
ALABAMA									
George H Lanier Mem Hospital	Medical Waste Incinerator	Chambers	3.50	73%*	2.55	1.13	94%	0.24	0.12
Dale County Hospital	Medical Waste Incinerator	Dale	0.29	73%*	0.21	1.13	94%	0.02	0.01
Flowers Hospital	Medical Waste Incinerator	Houston	0.61	73%*	0.44	1.13	94%	0.04	0.02
Southeast Alabama Med Center	Medical Waste Incinerator	Houston	6.29	73%*	4.59	1.13	94%	0.43	0.21
East Alabama Medical Center	Medical Waste Incinerator	Lee	4.20	73%*	3.06	1.13	94%	0.28	0.14
VA Med Center	Medical Waste Incinerator	Macon	6.99	73%*	5.10	1.13	94%	0.47	0.24
Edge Regional Medical Center	Medical Waste Incinerator	Pike	1.75	73%*	1.28	1.13	94%	0.12	0.06
Phenix Medical Park Hospital	Medical Waste Incinerator	Russell	2.80	73%*	2.04	1.13	94%	0.19	0.09
		Alabama Totals	26.42		**19.29**			**1.79**	**0.90**
		GRAND TOTALS	***430.83***		***314.50***			***1.79***	***0.90***

*For Medical Waste Incinerators the percent RGM is presumed to drop to 50% of the total released, after implementation of the MACT (See Table 4-2 in Volume III of *The Mercury Study*)

KINCHAFOONEE CREEK AIRSHED Fossil Fuel Electric Utility Boilers (Power Plants)

STATE/SOURCE	FUEL TYPE	COUNTY	RGM AIRSHED Pre-MACT (1994/1996) Total Hg Emissions (kg/yr)	%Hg as RGM*	RGM AIRSHED Pre-MACT (1994/1996) RGM Hg Emissions (kg/yr)	GROWTH Factor to 2010	Predicted % Reduction due to MACT	Predicted Total Hg Emissions in 2010 (kg/yr)	Predicted RGM Emissions in 2010 (kg/yr)
GEORGIA									
MITCHELL	COAL	Dougherty	14.65	30%	4.39	1.18	No MACT	17.29	5.19
ARKWRIGHT 1	COAL	Bibb	2.55	30%	0.77	1.18	No MACT	3.01	0.90
ARKWRIGHT 2	COAL	Bibb	3.34	30%	1.00	1.18	No MACT	3.94	1.18
ARKWRIGHT 3	COAL	Bibb	2.36	30%	0.71	1.18	No MACT	2.78	0.84
ARKWRIGHT 4	COAL	Bibb	2.30	30%	0.69	1.18	No MACT	2.72	0.81
SCHERER 1	COAL	Monroe	123.75	30%	37.12	1.18	No MACT	146.02	43.81
SCHERER 2	COAL	Monroe	62.16	30%	18.65	1.18	No MACT	73.35	22.01
SCHERER 3	COAL	Monroe	45.37	30%	13.61	1.18	No MACT	53.53	16.06
SCHERER 4	COAL	Monroe	37.32	30%	11.20	1.18	No MACT	44.04	13.21
WANSLEY 1	COAL	Heard	115.19	30%	34.56	1.18	No MACT	135.93	40.78
WANSLEY 2	COAL	Heard	115.19	30%	34.56	1.18	No MACT	135.93	40.78
YATES 1	COAL	Coweta	12.56	30%	3.77	1.18	No MACT	14.82	4.45
YATES 2	COAL	Coweta	10.77	30%	3.23	1.18	No MACT	12.70	3.81
YATES 3	COAL	Coweta	7.37	30%	2.21	1.18	No MACT	8.70	2.61
YATES 4	COAL	Coweta	12.36	30%	3.71	1.18	No MACT	14.58	4.37
YATES 5	COAL	Coweta	14.11	30%	4.23	1.18	No MACT	16.65	4.99
YATES 6	COAL	Coweta	37.85	30%	11.35	1.18	No MACT	44.66	13.40
YATES 7	COAL	Coweta	38.57	30%	11.57	1.18	No MACT	45.51	13.65
Georgia Totals			**657.76**		**197.33**			**776.16**	**232.85**
FLORIDA									
SCHOLZ	COAL	Jackson	6.84	30%	2.05	1.18	No MACT	8.06990	2.420971
SCHOLZ	COAL	Jackson	6.26	30%	1.88	1.18	No MACT	7.38715	2.216146
Florida Totals			**13.10**		**3.93**			**15.46**	**4.64**
	Grand Total		**670.86**		**201.26**			**791.61**	**237.48**

*** Tests of coal fired utility boilers have shown variability in the percentage of total mercury emissions that is RGM. An estimate of 30% RGM was presented in Table 4-2 of Volume III of the Mercury Study Report to Congress**

KINCHAFOONEE CREEK AIRSHED Miscellaneous Sources

STATE/SOURCE	FACILITY TYPE	COUNTY	RGM AIRSHED Pre-MACT (1994/1996) Total Hg Emissions (kg/yr)	%Hg as RGM	RGM AIRSHED Pre-MACT (1994/1996) RGM Hg Emissions (kg/yr)	GROWTH Factor to 2010	Predicted % Reduction due to MACT ** see notes **	Predicted Total Hg Emissions in 2010 (kg/yr)	Predicted RGM Emissions in 2010 (kg/yr)
GEORGIA									
Mutec	Battery Production	Muscogee	0.03	10%	0.00	1.18	No MACT	0.04	0.00
Duracell, USA	Battery Production	Troup	0.03	10%	0.00	1.18	No MACT	0.04	0.00
Riverwood Int'l Georgia	Pulp and Paper Recovery Furnace	Bibb	10.87	30%	3.26	1.18	No MACT	12.82	3.85
Georgia-Pacific Corp.	Pulp and Paper Recovery Furnace	Early	9.31	30%	2.79	1.18	No MACT	10.99	3.30
Georgia-Pacific Corp.	Pulp and Paper Recovery Furnace	Early	8.24	30%	2.47	1.18	No MACT	9.72	2.92
Georgia-Pacific Corp.	Pulp and Paper Recovery Furnace	Early	8.24	30%	2.47	1.18	No MACT	9.72	2.92
Packaging Corp. of America	Pulp and Paper Recovery Furnace	Lowndes	2.33	30%	0.70	1.18	No MACT	2.75	0.82
Packaging Corp. of America	Pulp and Paper Recovery Furnace	Lowndes	3.26	30%	0.98	1.18	No MACT	3.85	1.15
Packaging Corp. of America	Pulp and Paper Recovery Furnace	Lowndes	2.33	30%	0.70	1.18	No MACT	2.75	0.82
Procter & Gamble Cellulose	Pulp and Paper Recovery Furnace	Macon	9.45	30%	2.84	1.18	No MACT	11.15	3.35
ALABAMA									
Witco	Carbon Black Production	Russell	5.40	10%	0.54	1.18	No MACT	6.37	0.64
Mead Coated Board	Pulp and Paper Recovery Furnace	Russell	9.75	30%	2.92	1.18	No MACT	11.50	3.45
Mead Coated Board	Pulp and Paper Recovery Furnace	Russell	6.52	30%	1.96	1.18	No MACT	7.69	2.31
	Total		*75.75*		*21.63*			*89.39*	*25.53*

*** Based on recent emissions testing done to characterize mercury emissions from chlor-alkali facilities, the projected 2010 % RGM for the Olin facility was changed from 30% to 5%.**

KINCHAFOONEE CREEK AIRSHED Residential/Industrial Boilers

STATE/SOURCE	FACILITY TYPE	RGM AIRSHED Pre-MACT (1994/1996) Total Hg Emissions (kg/yr)	%Hg as RGM	RGM AIRSHED Pre-MACT (1994/1996) RGM Hg Emissions (kg/yr)	GROWTH Factor to 2010	Predicted % Reduction due to MACT	Predicted Total Hg Emissions in 2010 (kg/yr)	Predicted RGM Emissions in 2010 (kg/yr)
GEORGIA COUNTY								
Atkinson	**Res/Ind Boilers**	**0.48**	**30%**	0.14	**1.23**	**No MACT**	0.59	0.18
Baker	**Res/Ind Boilers**	**0.279**	**30%**	0.08	**1.23**	**No MACT**	0.34	0.10
Ben Hill	**Res/Ind Boilers**	**1.25**	**30%**	0.38	**1.23**	**No MACT**	1.54	0.46
Berrien	**Res/Ind Boilers**	**1.09**	**30%**	0.33	**1.23**	**No MACT**	1.34	0.40
Bibb	**Res/Ind Boilers**	**11.6**	**30%**	3.48	**1.23**	**No MACT**	14.27	4.28
Bleckley	**Res/Ind Boilers**	**0.806**	**30%**	0.24	**1.23**	**No MACT**	0.99	0.30
Brooks	**Res/Ind Boilers**	**1.19**	**30%**	0.36	**1.23**	**No MACT**	1.46	0.44
Calhoun	**Res/Ind Boilers**	**0.387**	**30%**	0.12	**1.23**	**No MACT**	0.48	0.14
Chattahoochee	**Res/Ind Boilers**	**1.31**	**30%**	0.39	**1.23**	**No MACT**	1.61	0.48
Clay	**Res/Ind Boilers**	**0.26**	**30%**	0.08	**1.23**	**No MACT**	0.32	0.10
Coffee	**Res/Ind Boilers**	**2.29**	**30%**	0.69	**1.23**	**No MACT**	2.82	0.85
Colquitt	**Res/Ind Boilers**	**2.83**	**30%**	0.85	**1.23**	**No MACT**	3.48	1.04
Cook	**Res/Ind Boilers**	**1.04**	**30%**	0.31	**1.23**	**No MACT**	1.28	0.38
Coweta	**Res/Ind Boilers**	**4.16**	**30%**	1.25	**1.23**	**No MACT**	5.12	1.54
Crawford	**Res/Ind Boilers**	**0.694**	**30%**	0.21	**1.23**	**No MACT**	0.85	0.26
Crisp	**Res/Ind Boilers**	**1.55**	**30%**	0.47	**1.23**	**No MACT**	1.91	0.57
Decatur	**Res/Ind Boilers**	**1.97**	**30%**	0.59	**1.23**	**No MACT**	2.42	0.73
Dodge	**Res/Ind Boilers**	**1.36**	**30%**	0.41	**1.23**	**No MACT**	1.67	0.50
Dooly	**Res/Ind Boilers**	**0.765**	**30%**	0.23	**1.23**	**No MACT**	0.94	0.28
Dougherty	**Res/Ind Boilers**	**7.44**	**30%**	2.23	**1.23**	**No MACT**	9.15	2.75
Early	**Res/Ind Boilers**	**0.916**	**30%**	0.27	**1.23**	**No MACT**	1.13	0.34
Fayette	**Res/Ind Boilers**	**4.82**	**30%**	1.45	**1.23**	**No MACT**	5.93	1.78
Grady	**Res/Ind Boilers**	**1.57**	**30%**	0.47	**1.23**	**No MACT**	1.93	0.58
Harris	**Res/Ind Boilers**	**1.37**	**30%**	0.41	**1.23**	**No MACT**	1.69	0.51
Heard	**Res/Ind Boilers**	**0.666**	**30%**	0.20	**1.23**	**No MACT**	0.82	0.25
Houston	**Res/Ind Boilers**	**6.89**	**30%**	2.07	**1.23**	**No MACT**	8.47	2.54
Irwin	**Res/Ind Boilers**	**0.668**	**30%**	0.20	**1.23**	**No MACT**	0.82	0.25
Jones	**Res/Ind Boilers**	**1.6**	**30%**	0.48	**1.23**	**No MACT**	1.97	0.59
Lamar	**Res/Ind Boilers**	**1.01**	**30%**	0.30	**1.23**	**No MACT**	1.24	0.37
Lee	**Res/Ind Boilers**	**1.26**	**30%**	0.38	**1.23**	**No MACT**	1.55	0.46
Lowndes	**Res/Ind Boilers**	**5.87**	**30%**	1.76	**1.23**	**No MACT**	7.22	2.17
Macon	**Res/Ind Boilers**	**1.01**	**30%**	0.30	**1.23**	**No MACT**	1.24	0.37
Marion	**Res/Ind Boilers**	**0.432**	**30%**	0.13	**1.23**	**No MACT**	0.53	0.16
Meriwether	**Res/Ind Boilers**	**1.73**	**30%**	0.52	**1.23**	**No MACT**	2.13	0.64
Miller	**Res/Ind Boilers**	**0.485**	**30%**	0.15	**1.23**	**No MACT**	0.60	0.18
Mitchell	**Res/Ind Boilers**	**1.57**	**30%**	0.47	**1.23**	**No MACT**	1.93	0.58
Monroe	**Res/Ind Boilers**	**1.32**	**30%**	0.40	**1.23**	**No MACT**	1.62	0.49
Muscogee	**Res/Ind Boilers**	**13.8**	**30%**	4.14	**1.23**	**No MACT**	16.97	5.09
Peach	**Res/Ind Boilers**	**1.64**	**30%**	0.49	**1.23**	**No MACT**	2.02	0.61
Pike	**Res/Ind Boilers**	**0.79**	**30%**	0.24	**1.23**	**No MACT**	0.97	0.29
Pulaski	**Res/Ind Boilers**	**0.626**	**30%**	0.19	**1.23**	**No MACT**	0.77	0.23
Quitman	**Res/Ind Boilers**	**0.171**	**30%**	0.05	**1.23**	**No MACT**	0.21	0.06
Randolph	**Res/Ind Boilers**	**0.62**	**30%**	0.19	**1.23**	**No MACT**	0.76	0.23
Schley	**Res/Ind Boilers**	**0.277**	**30%**	0.08	**1.23**	**No MACT**	0.34	0.10
Seminole	**Res/Ind Boilers**	**0.696**	**30%**	0.21	**1.23**	**No MACT**	0.86	0.26
Spalding	**Res/Ind Boilers**	**4.21**	**30%**	1.26	**1.23**	**No MACT**	5.18	1.55
Stewart	**Res/Ind Boilers**	**0.437**	**30%**	0.13	**1.23**	**No MACT**	0.54	0.16

STATE/SOURCE	FACILITY TYPE	RGM AIRSHED Pre-MACT (1994/1996) Total Hg Emissions (kg/yr)	%Hg as RGM	RGM AIRSHED Pre-MACT (1994/1996) RGM Hg Emissions (kg/yr)	GROWTH Factor to 2010	Predicted % Reduction due to MACT	Predicted Total Hg Emissions in 2010 (kg/yr)	Predicted RGM Emissions in 2010 (kg/yr)
Sumter	**Res/Ind Boilers**	**2.33**	**30%**	0.70	**1.23**	**No MACT**	2.87	0.86
Talbot	**Res/Ind Boilers**	**0.504**	**30%**	0.15	**1.23**	**No MACT**	0.62	0.19
Taylor	**Res/Ind Boilers**	**0.59**	**30%**	0.18	**1.23**	**No MACT**	0.73	0.22
Telfair	**Res/Ind Boilers**	**0.85**	**30%**	0.26	**1.23**	**No MACT**	1.05	0.31
Terrell	**Res/Ind Boilers**	**0.823**	**30%**	0.25	**1.23**	**No MACT**	1.01	0.30
Thomas	**Res/Ind Boilers**	**3.01**	**30%**	0.90	**1.23**	**No MACT**	3.70	1.11
Tift	**Res/Ind Boilers**	**2.7**	**30%**	0.81	**1.23**	**No MACT**	3.32	1.00
Troup	**Res/Ind Boilers**	**4.29**	**30%**	1.29	**1.23**	**No MACT**	5.28	1.58
Turner	**Res/Ind Boilers**	**0.672**	**30%**	0.20	**1.23**	**No MACT**	0.83	0.25
Twiggs	**Res/Ind Boilers**	**0.757**	**30%**	0.23	**1.23**	**No MACT**	0.93	0.28
Upson	**Res/Ind Boilers**	**2.03**	**30%**	0.61	**1.23**	**No MACT**	2.50	0.75
Webster	**Res/Ind Boilers**	**0.175**	**30%**	0.05	**1.23**	**No MACT**	0.22	0.06
Wilcox	**Res/Ind Boilers**	**0.541**	**30%**	0.16	**1.23**	**No MACT**	0.67	0.20
Worth	**Res/Ind Boilers**	**1.53**	**30%**	0.46	**1.23**	**No MACT**	1.88	0.56
ALABAMA COUNTY								
Barbour	**Res/Ind Boilers**	**7.56**	**30%**	2.27	**1.13**	**No MACT**	8.54	2.56
Bullock	**Res/Ind Boilers**	**3.28**	**30%**	0.98	**1.13**	**No MACT**	3.71	1.11
Chambers	**Res/Ind Boilers**	**11**	**30%**	3.30	**1.13**	**No MACT**	12.43	3.73
Dale	**Res/Ind Boilers**	**14.8**	**30%**	4.44	**1.13**	**No MACT**	16.72	5.02
Henry	**Res/Ind Boilers**	**4.57**	**30%**	1.37	**1.13**	**No MACT**	5.16	1.55
Houston	**Res/Ind Boilers**	**24.2**	**30%**	7.26	**1.13**	**No MACT**	27.35	8.20
Lee	**Res/Ind Boilers**	**25.9**	**30%**	7.77	**1.13**	**No MACT**	29.27	8.78
Macon	**Res/Ind Boilers**	**7.41**	**30%**	2.22	**1.13**	**No MACT**	8.37	2.51
Pike	**Res/Ind Boilers**	**8.21**	**30%**	2.46	**1.13**	**No MACT**	9.28	2.78
Russell	**Res/Ind Boilers**	**13.9**	**30%**	4.17	**1.13**	**No MACT**	15.71	4.71
Tallapoosa	**Res/Ind Boilers**	**11.5**	**30%**	3.45	**1.13**	**No MACT**	13.00	3.90
FLORIDA COUNTY								
Jackson	**Res/Ind Boilers**	**1.44**	**30%**	0.43	**1.23**	**No MACT**	1.77	0.53
	Grand Total	***253.78***		***76.13***			***298.91***	***89.67***

Appendix II

Emissions Reductions Programs and Initiatives

Appendix II
Emissions Reductions Programs and Initiatives

Air Standards and Programs Impacting
Hazardous Air Pollutant Emissions/Deposition to Watersheds

This Appendix summarizes the hazardous air pollutant (HAP) related standards and programs (including time-frames) that will impact emissions and ultimately air deposition into watersheds. The descriptive text and Table II.1. are based on EPA's document, the *Air-Water Interface Work Plan*, which can be accessed on the World Wide Web at http://www.epa.gov/ttn/oarpg/t3/reports/combined.pdf. Additional information on these programs can be found in EPA's *Deposition of Air Pollutants to the Great Waters, Third Report to Congress* (EPA-453/R-00-005, June 2000) which can be accessed on the World Wide Web at http://www.epa.gov/oar/oaqps/gr8water. This Appendix is only a summary of many diverse and dynamic activities, and should be viewed as informational, subject to change as programs and activities continue to develop.

1. ***National Technology-Based Standards*** - Under Section 112 (d) of the Clean Air Act as amended in 1990 (CAA), EPA is required to regulate stationary sources of 188 listed hazardous air pollutants (HAPs). On July 16, 1992, EPA published a list of 174 industry groups (known as source categories) that emit one or more of these air toxics. For listed categories of "major" sources (those that emit, or have the potential to emit, 10 tons/year or more of a HAP or 25 tons/year or more of a combination of HAPs), the CAA requires EPA to develop standards that require the application of air pollution reduction measures known as maximum achievable control technology, or MACT standards. During the process of developing standards for "major sources," EPA also determined that for some source categories MACT standards would be needed for both major and area sources. Otherwise, area sources are to be regulated under less stringent generally available control technology, or GACT standards. Area sources are defined as stationary sources which emit, or have the potential to emit less than10 tons per year of one HAP and less than 25 tons per year of multiple HAPs. Thus far, EPA has developed 56 stationary source standards, addressing 97 different types of sources.

The CAA provided a 10-year schedule in which to promulgate these MACT standards with a certain percentage of these standards being promulgated within 2, 4, 7 and 10-years. Some of the 10-year standards such as those for refractory manufacturing (many sources emit POM), and commercial industrial boilers (sources emit mercury, cadmium, lead) are still under development. EPA intends to address all the originally listed source

categories by November 2002.

2. ***Solid Waste Combustion Standards*** - Section 129 of the CAA directs EPA to establish new source performance standards, or NSPS, and emission guidelines under section 111 of the Act to limit emissions of dioxins and furans, cadmium, lead, mercury, and NOX, as well as particulate matter, opacity, sulfur dioxide, carbon monoxide, and hydrogen chloride from solid waste incineration units burning nonhazardous solid waste. These standards are essentially equivalent to MACT standards and apply to all subject solid waste incineration units without regard to "major" or "area" status. EPA has issued final standards and guidelines for large municipal waste combustors (MWCs), small MWCs, hospital/medical/infectious waste incinerators (HMIWIs) and commercial and industrial solid waste incinerators (CISWI). MWCs and HMIWIs account for 30 percent of the national mercury emissions to the air. By the time these rules for MWCs and HMIWIs are fully implemented, they will reduce mercury emissions from these sources by about 90 percent from baseline levels, and will reduce dioxin/furan emissions from these sources by more than 95 percent from baseline levels.

3. ***Residual Risk Standards*** - The residual risk standards program, required under sections 112(f) and 129(h)(3) of the CAA is designed to assess the risk from source categories after MACT standards and NSPS for solid waste incinerators are implemented. It is in the residual risk phase of the air toxics program that EPA determines the adequacy of the MACT standards already in place. Within 8 years of the promulgation of the MACT standard, EPA is required to assess whether further standards are needed to provide an ample margin of safety to protect public health, or to prevent (after considering costs, energy, safety and other factors) an adverse environmental effect. If EPA concludes that existing technology-based standards are not sufficient to meet these risk-based goals, EPA is required to promulgate additional regulations.

   In analyzing residual risk, EPA will conduct risk assessments consistent with the Agency's human health and ecosystem risk assessment technical guidance and policies. The EPA will use a tiered approach, usually first conducting a screening level assessment for a source category, and move to a refined assessment only where the risks identified in the screening assessment appear unacceptable. Depending on the characteristics of the hazardous air pollutants, these assessments will address single or multiple pathways of exposure (e.g., inhalation, consumption of contaminated fish) as well as human and ecological endpoints (e.g., terrestrial wildlife, fish-eating wildlife).

4. ***Area Source Standards*** - Under the urban air toxics program required under Section 112 (k) of the CAA, EPA must list at least 30 "area source" HAPs and then ensure that 90 percent of the area source emissions of the area source HAPs are regulated. The 30 HAPs were listed in the Integrated Urban Air Toxics Strategy (Strategy) published in the Federal Register on July 19, 1999. In order to begin meeting the 90 percent goal in the Strategy, EPA identified 13 new categories of smaller commercial and industrial operations or so-called "area" sources for regulation. Examples of area sources are dry cleaners, gasoline service stations, and public owned treatment works.

The EPA plans to finalize regulations for the recently listed 13 new area source categories by 2004. In addition, the EPA has completed or nearly completed regulations on an additional 16 area source categories. By 2003, EPA will have listed enough additional source categories for regulation in order to meet the requirement to regulate 90 percent of the area source emissions from all area source HAPs.

5. ***Seven Specific Pollutants*** - Section 112(c)(6) of the CAA lists seven specific pollutants (alkylated lead compounds, POM, hexachlorobenzene, mercury, PCBs, dioxins and furans) for special attention by EPA. The Act requires that EPA assure that stationary sources accounting for 90 percent of the emissions of these air toxics are subject to regulation. EPA published a list of source categories for regulation in the Federal Register in April 1998. Most of these source categories are already being regulated under the MACT program described in #1 above. An example of an area source category being regulated under this requirement is mercury cell chlor alkali plants (which emit mercury) and are a part of the chlorine manufacturing source category. EPA plans to complete these standards by 2003.

6. ***Utility Determination and Actions*** - As reported in the Mercury Report to Congress in 1997, utility plants (primarily coal-fired plants) emitted approximately 52 tons per year of mercury nationwide in 1994, which is almost 1/3 of the human made mercury emissions in the United States. During 1999 EPA gathered data through an Information Collection Request on mercury emissions from coal-fired electric utility power generation plants to evaluate the need for regulation of toxic air pollutants from these sources. The EPA, in conjunction with the U.S. Department of Energy and other parties, continues to assess the effectiveness and costs of various mercury pollution control technologies and pollution prevention options. Through an agreement with EPA, the National Academy of Sciences (NAS) recently completed a review of the available data on the health impacts associated with exposure to mercury. On December 14, 2000, EPA announced that it will regulate emissions of mercury and other air toxics from coal- and oil-fired electric utility steam generating units. EPA plans to propose MACT regulations by December 15, 2003 and issue final regulations by December 15, 2004.

7. ***Mobile Source Standards*** - While the toxic reductions from EPA's mobile source emission standards have been large, prior to 1990 EPA had no specific directions from Congress for a planned program to control air toxic emissions from mobile sources. However, in 1990 Congress amended the CAA adding a formal requirement to consider motor vehicle air toxics controls. Section 202(l) requires the Agency to complete a study of motor vehicle-related air toxics, and promulgate requirements for the control of air toxics from motor vehicles. The EPA completed the required study in 1993, and has recently updated the emissions and analyses. EPA proposed a rule to address the requirements of section 202(l) in July 2000 and issued a final rule on March 29, 2001. The March 2001 final rule identifies 21 mobile source air toxics and sets new gasoline toxic emission performance standards. It also sets out a Technical Analysis Plan to continue research and analysis on mobile source air toxics. Based on the results of that research, EPA will conduct a future rulemaking, to be completed no later than July 1,

2004, which will revisit the feasibility and need for additional controls for nonroad and highway engines and vehicles and their fuels. In addition, EPA has discretionary authority under CAA section 213(a)(4) to regulate HAP emissions from non-road mobile sources, which the Agency has not yet exercised.

Table II.1.: Office of Air Standard Setting Timeline for Standards Related to Toxics

National Technology-Based Standards		
Standards required by the Act in 1992 and 1994 (2&4-year)	Promulgate the 2&4 year air toxics standards.	Done
Standards required by the Act in 1997 (7-year)	Promulgate remaining 7-year air toxics standards.	Done
Standards required by the Act in 2000 (10-year)	Develop 10-year air toxics standards.	November 2002
Combustion standards	Promulgate remaining combustion standards.	November 2002
Residual Risk (RR) Program		
Residual risk	Propose any additional standards needed for coke ovens.	Under Development
	Propose any necessary residual risk standards for 2- and 4-year technology based standards.	2002-2004
Area Source Category Listing and Standards		
Update area source category list	Complete the area source list.	December 2003
Develop area source standards	Promulgate 13 area source standards.	2004
	Promulgate additional area source standards.	2006
	Promulgate last group of area source standards.	2009
Seven Specific Pollutants - Source Category List and Standards		
Standards for seven specific pollutants	Promulgate any standards necessary to meet requirement that sources accounting for 90% of emissions are subject to regulation for seven specific pollutants (to the extent not already achieved through the 2,4,7 and 10-	2003

Utilities Determination and Actions		
Information collection	Collect information from the utility industry, conduct analysis of potential control technologies.	Completed December 2000
Regulatory Decision/Action	Make regulatory determination for air toxics emissions (including mercury) from electric utilities.	Positive determination made December 2000
	Develop MACT regulation for utilities.	2001-2004
Office of Transportation and Air Quality(OTAQ) -Related Activities		
Section 202(l) rule	Final Rule identifies mobile source air toxics and sets new gasoline toxic emission performance standards. Also commits to further research.	Final Rule issued on March 29, 2001
Assessment activities	Final diesel health assessment document.	Under Development
	Propose re-assessment of mobile source HAP controls.	2003/2004

Table II.2. Status of Clean Air Act Standards Related to Control of Mercury By Source Category

Source Category	Status	Federal Register Citation
Electric Utility Boilers: coal combustion, oil, and natural gas http://www.epa.gov/ttn/atw/combust/utiltox/utoxpg.html	Proposal scheduled for Dec. 2003 and Final by Dec. 2004	12/20/2000, 65 FR 79825 - Regulatory Finding on the Emissions of Hazardous Air Pollutants from Electric Utility Steam Generating Units
Municipal waste combustion (small) http://www.epa.gov/ttn/atw/129/mwc/rimwc2.html	Final rules and guidelines complete	12/06/2000 65 FR 76349 - Subpart AAAA of 40 CFR Part 60 - New Source Performance Standards for Small Municipal Waste Combustion Units 12/06/2000 65 FR 76377 - Subpart BBBB of 40 CFR Part 60 - Emission Guidelines for Small Municipal Waste Combustion Units
Municipal waste combustion (large) http://www.epa.gov/ttn/atw/129/mwc/rimwc.html	Final rule and guidelines complete Fed plan complete	12/19/1995 60 FR 65387 - Subpart Eb of 40 CFR Part 60 - NSPS for Large Municipal Waste Combustors constructed after September 20, 1994 Subpart Cb - Emission Guidelines for Large Municipal Waste Combustors constructed on or before September 20, 1994 11/12/1998 63FR63191 - Federal Plan Requirements for Large Municipal Waste Combustors Constructed On or Before September 20, 1994

Source Category	Status	Federal Register Citation
Medical waste incineration http://www.epa.gov/ttn/atw/129/hmiwi/rihmiwi.html#RULE	Final rule and guidelines complete Fed plan complete	09/15/1997 62FR48348 - Subpart Ec of 40 CFR Part 60 - NSPS for Hospital/Medical/Infectious Waste Incinerators constructed after June 20, 1996 Subpart Ce - Emission Guidelines for Hospital/Medical/Infectious Waste Incinerators constructed on or before June 20, 1996 08/15/2000 65FR49739 - 40 CFR Part 62 - Federal Plan Requirements for Hospital/Medical/Infectious Waste Incinerators Constructed On or Before June 20, 1996
Chlor-alkali production http://www.epa.gov/ttn/atw/hgcellcl/hgcellclpg.html	Proposed Rule	07/03/2002 67FR44672 - 40 CFR Part 63 - National Emission Standards for Hazardous Air Pollutants: Mercury Emissions From Mercury Cell Chlor-Alkali Plants; Proposed Rules
Hazardous waste combustors http://www.epa.gov/hwcmact/	Rule promulgated Interim Standards Final Rule	09/30/1999 64 FR 52827 - 40 CFR Parts 60, 63, 261, and 270 - Part 63 Subpart EEE - NESHAP for Hazardous Air Pollutants for Hazardous Waste Combustors. [Note: On July 24, 2001, the U.S. Court of Appeals issued a decision vacating the HWC MACT standards.] 02/13/2002 67 FR 6791 - 40 CFR Parts 63, 264, 265, 266, 270, 271 - NESHAP: Interim Standards for Hazardous Air Pollutants for Hazardous Waste Combustors (Interim Standards Rule)

Source Category	Status	Federal Register Citation
Portland cement, excluding hazardous waste fired http://www.epa.gov/ttn/atw/pcem/pcempg.html	Rule promulgated	06/14/1999 64 FR 31898 - 40 CFR Part 63 National Emission Standards for Hazardous Air Pollutants for Source Categories; Portland Cement Manufacturing Industry
Commercial/Industrial boilers: coal and oil http://www.epa.gov/ttn/atw/combust/boiler/boilerpg.html	Under development	
Pulp and paper manufacturing cluster http://www.epa.gov/ttn/atw/pulp/pulppg.html	Rule promulgated	01/12/2001 66 FR 3180 - 40 CFR Part 63 Subpart S - NESHAP for Kraft Chemical Recovery Combustion Sources at Kraft, Soda, Sulfite, and Stand-Alone Semichemical Pulp Mills
Commercial and Industrial Solid Waste Incinerators http://www.epa.gov/ttn/atw/129/ciwi/ciwipg.html	Final rule and guidelines complete	12/01/2000 65 FR 75337- Subpart CCCC of 40 CFR Part 60 - NSPS for Commercial/Industrial Solid Waste Incinerators constructed after November 30, 1999 Subpart DDDD of 40 CFR Part 60 - Emission Guidelines for Commercial/Industrial Solid Waste Incinerators constructed on or before November 30, 1999